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U. S. DEPARTMENT OF AGRICULTURE.

Report No. 65.

# PHYSIOLOGICAL STUDIES

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# LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF SOILS,
*Washington, D. C., March 24, 1900.*

SIR: I have the honor to transmit herewith a manuscript concerning some physiological studies of Connecticut leaf tobacco by Dr. Oscar Loew, of the Division of Vegetable Physiology and Pathology. These investigations are in continuation of the cooperative work between this Division and the Division of Vegetable Physiology and Pathology in carrying out in the broadest sense the tobacco investigations authorized by Congress and in the critical and exhaustive study of the possibilities of the soils of the Connecticut Valley.

Respectfully,

MILTON WHITNEY,
*Chief of Division.*

Hon. JAMES WILSON,
*Secretary of Agriculture.*

# LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY,
*Washington, D. C., March 20, 1900.*

SIR: In accordance with a plan of cooperative work between this Division and the Division of Soils, I respectfully submit herewith the manuscript of a report on some physiological investigations of Connecticut leaf tobacco, by Dr. Oscar Loew. The work deals with a number of questions relating to the physiology of the leaf and the changes which take place during the processes of curing and sweating.

Respectfully,

B. T. GALLOWAY,
*Chief of Division.*

Prof. MILTON WHITNEY,
*Chief, Division of Soils,*
*In Charge of Tobacco Investigations.*

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# PHYSIOLOGICAL STUDIES OF CONNECTICUT LEAF TOBACCO.

## GENERAL PHYSIOLOGY OF THE TOBACCO PLANT.

### THE FACTORS OF DEVELOPMENT.

The interest connected with the tobacco plant is not only of an agricultural and commercial nature[1] but is also to a considerable degree of a physiological and chemical character. First of all the minuteness of the seed strikes us as peculiar when compared with the large plant developed in but ninety days rivaling in extent of leaf surface most other cultivated plants of equal age. This rapid development requires a steady and full nutrition, if the leaves are to become of the desired size and quality. In order to accomplish this result the roots must be able to grow and extend with corresponding rapidity, requiring for this purpose not only a loose humus or a fine sandy soil to the depth of several feet, but also the presence of all necessary mineral nutrients in most easily assimilable form. The soil must, on the one hand, admit air freely to the finest rootlets to satisfy the wants of respiration and, on the other hand, it must be of such quality as not to part with its moisture too easily in a period of dry weather. The nature of the subsoil is also of great importance, since when it is impermeable the stagnant water is just as detrimental to the roots as too great loss of water on account of excessive permeability of the soil.[2]

The abnormal physiological condition created by the mutilating (topping and suckering) of the plant in order to obtain suitable leaves for the requirement of the tobacco manufacturer is also of interest. Further points of consideration are the production of the enzyms necessary for the processes of curing and sweating and, finally, the production

[1] The annual total tobacco production of the globe is estimated by Darmstädter to be nearly 1,000,000,000 kilograms.

[2] For full information on tobacco soils see Bulletin No. 11, Division of Soils, Tobacco Soils of the United States, 1898, by Milton Whitney. A tropical temperature might favor the development of the root in humus soil to such an extent that relatively less of mineral nutrient for the unit of soil will suffice for a normal plant development. The fact that some tobacco soils of Sumatra contain less of nutrients than tobacco soils in northern countries and still produce excellent crops is thus explained by A. Mayer.

of nicotine. All these points are of particular interest. Unless all the conditions necessary for the normal development of the plant are united various dangers menace the crop; and there may even be the development of a singular disease which annually causes immense damage, namely, the mosaic disease.

Among the various tobacco soils of Connecticut there are some that are better suited for broad leaf than for Havana seed as, for example, the soil at East Hartford, Conn., where the culture of the latter had to be given up, the fine cinnamon-brown color not having been attained on this kind of soil.

The weather also constitutes one of the most important factors as to the quality of the tobacco. Too moist as well as too dry years are injurious; the latter, however, more so than the former, since the leaves remain smaller and grow thick and become relatively too heavy; and, furthermore, show insufficient elasticity and frequently burn poorly. In too moist years the leaves remain weak, are attacked easily by fungi and, moreover, the aroma of the tobacco is injured. In rainy weather, especially when the temperature is rather low, the amount of acid in the leaves is also increased and this may exert a detrimental effect on the oxidizing enzyms in the curing process when the tobacco is harvested in such a condition. The oxidizing enzyms are the promoters of all desirable changes in the curing and the sweating process. Variable weather is the best. Van Bemmelen[1] says that the weather in Sumatra is generally more favorable than in Java where frequently extremes are observed. In Deli, Sumatra, occasional rains occur even during the dry monsoon. After twenty days of dry weather a rain is much desired there for tobacco. Forty days of dry weather are considered very injurious. The short showers falling through the period of tobacco growing are considered so important that a continuous record is kept on many tobacco plantations. It is principally the great rapidity of development that causes the fineness of the ribs and veins and the elasticity, making the tobacco leaves from Sumatra unsurpassed as wrappers.[2]

On warm bright days not only is much more carbon assimilated—that is, more starch, the mother substance of all the other organic constituents of the plants, is formed but also the respiration is increased by the high temperature, although not to such an extent as to consume all the starch increased by the bright light. All processes of metabolism are thus promoted by warm and bright days, undesirable by-products may be destroyed and favorable products formed. How differences of temperature influence the intensity of the respiration process may be seen from the following data. While Behrens observed, for 100 grams fresh tobacco leaf at 21° C. (69.8° F.), a production of 0.254 grams of carbonic acid in ten hours, Dêherain and Moissan ob-

[1] Landw. Vers. Stat., vol. 37, p. 385.

[2] Report No. 62, U. S. Department of Agriculture. M. L. Floyd.

served in the same length of time as much as 1.325 grams at 40° C. (107.6° F.)—that is, more than five times as much.[1]

Soil, climate, rich and uniform manuring, careful curing and proper fermenting must be combined in order to yield a commercial product of superior quality. The value of tobacco depends probably more largely upon its quality than is the case with any other farm product.

The tobacco seed seems somewhat neglected by nature, since the amount of reserve material to support the young plant in its first stage is exceedingly minute. It takes 21 seeds to weigh 1 milligram; consequently the initial growth is but slow and much in disproportion to the later energetic development, the tobacco after being planted in the field often reaching its full development in forty-five days in Florida. The reserve material of the endosperm of the seed consists, according to Harz, essentially of fat and protein matter, and is, like the 0.6 mm. long embryo, devoid of starch. The young delicate plant soon consumes this small amount of reserve material and is forced to prepare its own organic matter in a much earlier stage than is for instance a corn, barley, or bean plant. Unusual care is required in the seed bed, which if too moist will favor fungous diseases among the young plants. A moderately dry soil, occasionally sprinkled, is preferable.

Much has been written about the proper manuring of the tobacco field. General experience indicates that barnyard manure is here superior to all other fertilizers. An addition, however, of some superphosphate of lime, and carbonate or silicate[2] of potash (5 parts per 1,000 of barnyard manure), and Chile saltpeter (not over 15 parts per 1,000 of the barnyard manure) the last mentioned to be applied in the spring and the other materials in the autumn, is recommended by some. The advantage of the barnyard manure consists in loosening the soil, increasing its absorptive power by formation of humus and yielding up its insoluble nourishing compounds gradually in a soluble condition. It makes, in short, a uniform nutrition of the plant during the entire season more easily possible than a mere mixture of mineral fertilizers can do.[3] The tobacco thus grown is of the best quality and least subject to the mosaic disease.

---

[1] Sand leaves, which are generally poorer in respiration material, produced only 0.568 grains at 42° C.

[2] Sulphate and chlorid are to be avoided.

[3] Of other materials that have been applied with great advantage should be mentioned cotton-seed meal and castor pomace with cotton-hull ashes. The amount of fertilizers applied per acre of a tobacco field varies from 200 pounds to a ton. Nitrogenous manures applied in very large quantities increase the percentage of nicotine and protein and also, naturally, the total yield, but the quality may be injured. Thick ribs and a poor burn have been observed in such cases.

Behrens (Landw. Vers. Stat. 52, 242) calls attention to the fact that the increase of easily soluble salts in the soil, as is the case when merely mineral manures are applied, leads to the formation of thicker leaves. This modified anatomical structure also caused by very dry seasons, decreases the amount of transpiration from the leaves Such thick leaves require a longer time to cure, and thus the danger of pole burn and other fungous diseases is increased.

A Havana seed plant, after topping and suckering, is generally left to develop about 15 leaves, while the Connecticut seed leaf is allowed to develop but 13, the latter, however, being larger than the former.[1] Of one Havana seed plant with 15 leaves, 10 leaves were found by the writer to average 44 cm. in length and 20 cm. in width, while the 5 largest leaves averaged 52 cm. in length and 24 cm. in width. On another field the length and width of all 17 leaves of one plant were measured and the average taken. The average was—length, 45 cm.; width, 28 cm. An unusually large Havana leaf measured 75 cm. in length and 39 cm. in width. The proportion between the length and width of full-grown leaves varies considerably even on the same field.

Two ripe leaves of medium size each measuring 44 cm. in length and 24.1 and 25.5 cm., respectively, in width, weighed 6.55 and 8.40 grams, respectively, in the dried state. In order to determine the weight for 1 square meter 100 square centimeters were cut from different leaves, partly avoiding the midrib and partly taking it in. The fresh weight varied between 3.01 and 4.12 grams, averaging 3.5 grams in the fresh and 0.595 grams in the dry state. This would give for 1 square meter 59.5 or about 60 grams. It nearly agrees with the result obtained by H. J. Patterson, who found for Maryland tobaccos the maximum average dry weight to be 65.5 grams. According to Behrens the weight of Sumatra tobacco leaves varies between 52 and 90 grams per square meter.[2] Since the quantity of starch differs very much in leaves cut in the morning and those cut in the evening, considerable difference in weight should not surprise us. The figures given above refer to starch-free leaves.

### REMARKS ON THE CONTENTS OF THE TOBACCO LEAF.

The epidermis of the tobacco leaf develops partly into noncapitate hairs and two kinds (long and short ones) of capitate gland hairs. The apical cells of the gland hairs contain chlorophyll granules when young and generally in each cell a radiary group of calcium oxalate crystals. Later on the gland hairs contain resin and other matters, and a dilute alcoholic iodine solution stains the contents a deep brown. The dissolved albumin content in the plant juice varies considerably with the age of the leaf. The lower or sand leaves contain, on becoming yellow, but very little or no soluble albumin, while the full-grown green leaves on the same plant are rich in it. This is to be expected, since only the normally green chlorophyll bodies can produce sufficient sugar to make protein production considerable. The "ripe" leaves, however, are richest in soluble albumin. It may also be mentioned that tobacco attacked

[1] In Deli, Sumatra, 22 leaves are left when the tobacco is on good soil, but on poor soil only 14 leaves are left. The leaves in Sumatra reach 42–46 cm. in length and from 31–38 cm. in width. (Van Bemmelen.)

[2] These numbers vary very much from the numbers given by Barth (Landw. Ver. Stat., vol. 39, p. 92) who states that dried coarse leaves may weigh per square meter 200 grams and more. There may be an error in his calculations.

by the mosaic disease contains much less soluble albumin than normal leaves, for an equal surface. The latter give a juice which, upon being heated, forms a large amount of flocculent coagulum; the former, however, hardly more than a turbidity. This is not surprising, since the chlorophyll bodies are affected in the mosaic disease and hence can not furnish a sufficient amount of sugar for an abundant protein formation. The fat content varies considerably, the amount being—other things being equal—probably influenced by the weather, since low temperature will retard growth and respiration more than it does assimilation; hence some sugar that would otherwise have been consumed by respiration may be transformed into fat, if the conditions for protein formation are not all fulfilled at that time. The sugar is the material from which not only the cellulose, starch, fat, and protein, but also the wax, tannin, and resin of the leaves are produced.

The most interest, of course, is attached to the formation of nicotine, which alkaloid, according to Pinner, has to be considered as pyridyl-N-methyl-pyrrolidine. It is probably formed from decomposition products of proteins and plays no further physiological rôle in the plant. The malic acid of the leaf may also participate in the synthesis of nicotine, since nicotinic acid can easily be reached by transformations of malic acid. The object of the nicotine production in the wild plant is possibly to keep off depredating enemies among the insects, but the amount of this poison in young plants cultivated in our climate is too small to kill the insects feeding on the leaves.[1] Even the ripe leaves, richest in nicotine, are attacked with impunity by certain caterpillars, grasshoppers, and the "suck fly," a heteropterous insect (Dicyphus minimus). The nicotine, according to Wizsman-Leyden, is contained especially in the cells underneath the hairs.[2] Adolf Mayer found that the veins contain much less nicotine than the lamina.

The fresh leaves contain relatively but little wax, resin, lecithin, tannin, and calcium oxalate, the latter occurring as a sandy crystalline deposit, especially in mesophyll cells. The oxalic acid, as well as the citric and malic acids of the leaves, is probably an oxidation product of sugar.[3] A part of these acids occurs in the form of a neutral, another part as acid salts.[4] The cell sap, therefore, shows an acid

[1] The amount of nicotine formed depends largely upon climate and weather (cf. A. Mayer, Landw. Vers. Stat. vol. 38, 453 [1891]).

[2] Südd. Apoth. Zeitg., 1898.

[3] According to Kissling the amount of oxalic acid varies in commercial tobaccos between 0.96 and 3.72 per cent of the dry matter; that of citric acid between 0.55 and 8.73; that of malic acid (in form of neutral and also acid salts) between 3.49 and 10 per cent. (Chem.-Zeitung, 1899, No. 1.)

[4] Behrens (Landw. Vers. Stat. vol. 52) found from 5.79 to 9.79 per cent malic acid in form of soluble salts in the tobacco leaf (dry matter) and infers that it is the hygroscopic quality of these salts that keeps the leaves from drying up too easily, which thus preserve a certain softness and elasticity. The more malic salts are present the more "life" is in the finished tobacco leaf. Stored under equal conditions, leaves rich in malic salts may contain 3 per cent more water than leaves poor in them.

reaction. It seems of special interest to determine here the degree of acidity, since the amount of enzyms of importance in the curing and sweating process may be decreased by acids.[1]

ACID CONTENT IN DIFFERENT PARTS OF THE TOBACCO PLANT.

The free acid of the juice was titrated in the usual way by one-tenth normal soda solution and calculated as free malic acid. Although in reality this acid is present as an acid salt and not as free acid, it makes no difference as to the number of unneutralized carboxyl groups, and the data obtained can serve for comparison. The juice was prepared by grinding the objects with the aid of some pure quartz sand and pressing the pulp through thin flannel. The juice of the leaf had to be mixed, however, previously to titration, with an equal volume of strong alcohol to precipitate suspended chlorophyll grains, otherwise the point of neutralization could not be observed with sufficient precision on blue litmus paper, still less distinctly on violet litmus paper. Filtration, after the addition of the alcohol, was not found necessary previous to the titration.

The amounts of free acid in the different organs are, of course, subject to variation within certain limits, according to the atmospheric conditions and the influence of direct sunlight. Thus the writer has observed with the flowers of *Ipomœa triloba* that warm weather with bright sunshine diminishes the acidity, while cool and rainy weather increases it, whereby the blue flowers turn red; and further, the acidity is greater in the morning than in the evening, which the writer also observed in the case of tobacco. The custom of harvesting tobacco on bright, sunny days has therefore a sound physiological foundation.

The following data were observed:

| Part of plant. | c. c. $\frac{n}{10}$ soda solution required by 10 c. c. juice | Per cent of free malic acid in juice. |
|---|---|---|
| Small roots | 0.5 | 0.033 |
| Pith | .8 | .052 |
| Bark | 1.4 | .092 |
| Midrib of leaf (evening) | 1.6 | .105 |
| Midrib of leaf (evening) | 1.5 | .098 |
| Midrib of leaf (morning) | 2.1 | .138 |
| Lamina of ripe leaf *a* | 4.4 | .294 |
| Lamina of ripe leaf | 4.2 | .277 |
| Lamina of young suckers | 2.2 | .145 |
| Lamina of young suckers | 2.4 | .156 |

*a* Midrib and large side ribs removed.

We learn from these numbers that the least amount of acid is contained in the small roots and in the pith; also that the lamina contain much more than the rib, and that the young leaves contain less than the ripe old leaves.[2]

[1] Certain fungi, as, for example, Oospora Nicotianæ, will grow on fermented tobacco only in the presence of some free organic (malic) acid (Splendore). This shows also in this respect an unfavorable effect of the acidity.

[2] These relations may differ in different plants. Thus Kraus has observed less of free acid in the leaf of *Sempervivum* than in the root.

## RIPENING OF THE TOBACCO LEAF.

The ripening process, in a normal physiological sense, refers to the fruit and implies the normal formation of the embryo and the filling up of the reservoirs of the fruit with the proper material for the young growing plant. The ripening of the tobacco leaf on a topped and suckered plant, however, implies an abnormal accumulation of organic matters in the leaves, brought on by preventing their transportation to the forming seeds and shoots or suckers, which would otherwise have consumed a great deal of these substances. The "ripening" of the tobacco leaf is, in other words, not a physiological, but a pathological phenomenon. By the accumulation of nicotine, oxidizing enzyms, and acids a state is finally reached in which the normal deep green color of the chlorophyll grains gives way to a yellowish color. A "ripe" leaf contains per 100 square centimeters an average of 0.164 gram of matter soluble in boiling water, while a young leaf contains only 0.066, the former having, therefore, for an equal surface about 2.5 times as much soluble organic matter as the latter. As to the total weight, a ripe leaf weighs from 1.3 to 1.5, on the average 1.4, times as much as an equal surface of a young leaf of the same plant. It is especially the nicotine and protein compounds that increase in the ripe leaf, a fact of which anyone can soon convince himself by a comparison of the reaction caused by phosphotungstic acid in the juices of ripe and unripe leaves. The amount of water in ripe leaves averages roughly 83 per cent and in young leaves 88 per cent, that is, when compared in nearly starch-free condition after being kept for two days in darkness.

But it is not only the increase (relative and absolute) of reserve materials and of products of metabolism that is brought on by topping and suckering; it is also the enlargement of the leaf surface, which may amount to over 50 per cent above the normal. The suckering exerts these influences to a higher degree than the topping (Behrens). A further influence, due to differences in topping, has been observed, low topping producing thicker leaves than high topping.

An important factor is the proper time for topping and suckering. The suckers must be removed neither too soon nor too late. In the former case, too much protein would be left in the full-grown leaf; in the latter, too much nicotine might be lost from it. Goff observed that in moderate climates the tobacco leaves increased in weight at least to the thirty second day after the topping had been performed. A ripe leaf is recognized by the planter not only by the setting in of a yellowish coloration and a peculiar rough feeling to the touch, but also by the facility with which the lower epidermis peels off and the leaves break ("snap") when folded between the fingers.

As to the so-called "overripe" leaves, they contain, like the young leaves, relatively more water and less organic matter than the ripe leaves. By the stoppage of the functions of the chlorophyll grains, which gradually change in the overripe leaves, new production c

organic matter is prevented, while consumption still proceeds. With the young leaves it is the growth, besides the respiration, that consumes material and prevents its accumulation.

In comparing the undiluted juices of overripe and ripe leaves, great differences can at once be noticed by adding a double volume of alcohol or phosphotungstic acid, the ripe leaves yielding a much more copious precipitate than the overripe ones. The juice of ripe leaves is, further, more slimy and more acid. From the central part of the leaves 100 sq. cm. were cut out of each side of the midrib and ground with some quartz sand and 10 c. c. of water to a fine pulp in a mortar and directly titrated, after the addition of 10 c. c. of strong alcohol. The result was as follows:

| | c. c. $\frac{n}{10}$ soda solution for 200 sq. cm. of leaf. | Content of free malic acid in 100 sq. cm. of leaf. |
|---|---|---|
| | | *Gram.* |
| Ripe upper leaf | 3.8 | 0.012 |
| Sand or lower leaf | 3.0 | .010 |

From the center of another field, ripe upper leaves and lower or sand leaves of the same plant were collected. The lower leaves were of a lighter green than the upper ones. The juices were prepared as usual, and 10 c. c. titrated. The juice of the upper leaves required 4.2 c. c. of one-tenth normal soda solution, while that of the lower leaves required but 3.2 c. c. Since it is the sugar principally that gives rise to the formation of acid, we should not be surprised at finding more acid in the upper leaves than in the lower, as the production of sugar and starch depends upon the access of light to the chlorophyll bodies.[1]

Well-ripened leaves, rich in oxidizing enzyms and in nicotine, and very rich in soluble matter generally, will yield when normally cured the so-called "gummy" leaves with a well-developed "grain," and after a thorough sweating a fine aroma, while unripe leaves will show injuries after the sweating process and yield, like the sand leaves and overripe leaves, an inferior product. Hence, the single-leaf-curing process would be preferable to the method of curing on stalk, since the overripe, ripe, and unripe leaves are in the latter method harvested together, to be cured under equal conditions.

It is not the object of this report to give an exhaustive critical comparison of these two methods.[2] Where labor is very expensive, the method of single-leaf curing may be out of the question. The same may be said for the priming of the very large leaves of Connecticut seed-leaf tobacco. Here in the removal of the lower leaves at their

[1] In organs free of chlorophyll, as the flowers, the direct sunlight can, on the contrary, exert a diminishing effect on the amount of acid.

[2] The chemical analysis of fully ripe leaves cured after these two methods does not show essential differences. (Behrens.)

ripening stage the upper leaves may easily be broken or lacerated, thus leading to a considerable loss.

The single-leaf curing, a process that seems to grow more and more in favor with the farmers in certain States, takes one-third less time than stalk curing, permits the harvesting of about double as many leaves as the curing on the stalk, gives a more uniform product, and permits the gathering of top suckers, which may form good wrappers.[1] The stalk is here longer in the field and continues to produce healthy leaves from the suckers.

## ENZYMOLOGY OF THE TOBACCO PLANT.

The important physiological rôle of enzyms for every organism is well known. Some enzyms are found in all organisms, others only in a few, and some may even occur only in one. Three physiological groups of enzyms can be distinguished: (1) Such as are most intimately and directly connected with the nutritive processes, as diastase and proteolytic enzyms; (2) such as bring on coagulation—the clotting enzyms, as pectase and thrombase; and (3) such as cause oxidation—that is, the oxidases.

It was to be expected from analogy that enzyms of the first and third groups would occur in the tobacco plant, and, since the activity of the enzyms is not only of physiological value to this plant itself, but in this case is also of practical importance to the tobacco planter, it was important to prove their presence beyond a doubt. Two oxidizing enzyms have been shown by the writer to exist in the tobacco plant,[2] and recently a third one has also been observed. This will be described further on.

## DIASTASE IN THE TOBACCO LEAF.

The disappearance of starch in the early part of the curing process is due to the presence of diastase. It has been asserted that diastase does not occur in leaves and that protoplasm itself is capable of doing the same work.[3] This appears very improbable, since both starch and protoplasm are insoluble in water. It is, however, somewhat difficult to demonstrate the presence of small quantities of diastase in the juice of leaves, since some can easily be retained by the pressed residue. Brown and Morris have observed that powdered leaves, if directly digested with some starch paste, gave a diastatic action of much greater intensity than was obtained when juice corresponding to that amount of leaf substance was applied.

---

[1] This method is practiced extensively by Mr. G. Barnes, of Hatfield, Mass.

[2] Report No. 59, U. S. Department of Agriculture.

[3] Wortman observed that leaves killed with chloroform or kept in an atmosphere of carbonic acid show no decrease of starch, and hence inferred the absence of diastase in leaves; but this is not justified, for several reasons. Recently it has been shown by A. F. Woods that diastase is easily changed by oxidizing enzyms. Furthermore, Vines, and also Jentys, have given new proofs of the presence of diastase in leaves.

The presence of diastase in the tobacco leaf was demonstrated by the writer as follows: Four large healthy leaves were well crushed in a mortar with some sand and pressed. The filtered juice was precipitated with alcohol, and the precipitate, after being washed with alcohol of 90 per cent and pressed between filter paper, was digested with 10 c. c. of highly diluted starch paste at 60° C. (140° F.). The iodine test, applied to a drop of the liquid on a white porcelain plate, showed that the starch gradually diminished and disappeared after two hours. Leaves kept for eight days in darkness and near death by starvation did not, when so examined, show any diastase content. This would probably also prove the case with leaves from the curing barn. The destructive effect of oxidase on diastase (Woods) comes into play here.

### PROTEOLYTIC ENZYM IN THE TOBACCO LEAF.

The decrease of protein in the tobacco leaf, while curing is going on, can be ascribed only to a proteolytic enzym. The amount of it, however, is probably small, since the coagulable albumin contained in the juice of tobacco leaves decreases very slowly; even after several weeks leaves taken from the barn may show some of it. It may be possible that the oxidizing enzyms injure this enzym, as they do the diastase, and thus prevent an accumulation beyond mere traces in the fresh leaf. Many authors have encountered difficulties in attempting to prove the presence of proteolytic enzyms in green leaves and fruits. One of the causes of this failure may be that blood fibrin, or coagulated egg albumen, has been used for the test; while certain proteolytic enzyms may exist which can easily peptonize dissolved albumen without being capable of dissolving fibrin or coagulated albumen. Indeed, there may exist a great variety of proteolytic enzyms. Thus, Bourquelot and Hérissey have shown an enzym to exist in fungi which is capable of easily digesting casein, while it can not dissolve fibrin. The writer's experiments with casein and fibrin, in attempting to prove the presence of a proteolytic enzym in the fresh tobacco leaf, were not conclusive, no visible solution of these proteins taking place when digested for several days at 40° C. The method of Fermi and Buscaglioni also proved unsuccessful. These authors recommend a gelatin solution that solidifies at the ordinary temperature. The liquid to be tested is, in the presence of an antiseptic substance, left upon the gelatin in the test tube for several days. The presence of even a trace of proteolytic enzyms will soon be indicated by the liquefaction of the gelatin below the line of demarcation. The principal objection which may here be raised is that proteolytic enzyms may exist which can act on gelatin only at a higher temperature—that is, above the temperature 20° to 22°, at which the usual gelatin preparation liquefies by melting.

In the following experiment the test recommended by Märtz was adopted. Ten fresh and 10 starved leaves, of as nearly the same size

as possible, were rubbed with sand to a fine pulp and the juices pressed out. A portion of each of these juices was kept separate as control, while the chief portions were mixed with an equal volume of a solution of albumin. This solution was obtained by pressing the white of an egg through linen, diluting the liquid with fifteen times its bulk of water and filtering. A portion of the albumin solution was also diluted with an equal volume of water and kept for control. All liquids were kept at from 18° to 22° C. in closed test tubes which had received an addition of ether to exclude bacterial development. After nine days the filtered liquid received an addition of some nitric acid and the precipitate formed was left one day to settle. The volume of the precipitate showed a moderate decrease in the juice of the fresh leaves and a considerable decrease (about one-half) in that of the starved leaves; therefore the existence of a proteolytic enzym can not be doubted, but it differs from the ordinary trypsin, inasmuch as it can not attack fibrin and casein under ordinary conditions, while it can attack dissolved albumin.

As to the first-mentioned control cases of the juices which had not received the addition of egg albumin, the soluble albumin originally present as reserve matter in the juice was found fully digested in the juice of the starved, but not yet completely so in that of the fresh leaves.

## IS A CELLULOSE-DISSOLVING ENZYM (CYTASE) PRESENT IN TOBACCO LEAVES?

Cytohydrolytic enzyms, especially such as easily attack hemicelluloses, occur in phanerogamous plants and are not identical with diastase, as Newcombe[1] has demonstrated. He found such an enzym in the cotyledons of seedlings of Phœnix dactylifera and of Lupinus albus and confirmed its presence in the malt of Hordeum vulgare.

Parasitic fungi, such as eat through wood, must contain enzyms which dissolve the genuine cellulose with great facility. Various observations, especially those of Dr. Erwin F. Smith on bacteria acting as plant parasites, leave no doubt as to the occurrence of such enzyms also in certain species of bacteria.

The fact that tobacco leaves lose more or less of their original degree of tenacity and cohesion, and even show holes when subjected to sweating in a too moist condition, appears to find a simple explanation in the action of bacteria, which may occur in the presence of too much moisture. But it would have to be assumed that cellulose dissolving bacteria, of which not many kinds are known, are always present whenever too much water is applied to the tobacco. It was therefore of interest to test whether cytase, which has been shown to be present in certain germinating seeds, was also contained in the tobacco leaf itself, or whether it was eventually formed from another enzym in the

[1] Annals of Botany, March, 1899.

process of curing; in other words, whether the abnormal softening of the leaves was accomplished without the action of bacteria. Parts of cured tobacco leaves and of fresh leaves, the latter previously dried at 45° C., were therefore moistened with water and left for twelve days at from 45° to 50° C. in test tubes with as little 20 per cent alcohol as sufficed to cover them. Bacterial development was thus excluded, but not the action of enzyms. Vapor of chloroform in closed flasks was also used in place of the 20 per cent alcohol. The result was that the green leaves (healthy as well as mosaic diseased leaves) did not show any decrease of tenacity, but the cured leaves did, although only to a slight degree. From sweated leaves a concentrated extract was now made at the ordinary temperature, a second portion of leaves being extracted with the first extract obtained, and so on until the fourth portion was extracted with the same water. The concentrated extract thus obtained was saturated with ammonium sulphate, whereby a copious precipitate of proteins of a very dark brown color was formed. This precipitate was freed of most of the adhering salt solution by pressure between filter paper, dissolved in a little water, and in presence of chloroform permitted to act for five days on a small piece of fermented leaf at 50° C. Although bacterial growth was here successfully prevented, the leaf was very much softened and lost most of its former tenacity. Nevertheless, the writer is not yet fully prepared to give a decisive answer as to the nature of the cellulose injuring agency in the sweating leaf.[1]

### TEST FOR OXIDASE AND PEROXIDASE IN THE FRESH TOBACCO LEAF.

Although in report No 59 (p. 28) the way of testing for the oxidizing enzyms of tobacco was mentioned, some further remarks on this subject will not be superfluous for those who intend to make further observations on these enzyms. The principal reagent, as has been mentioned, is guaiac resin in absolute alcoholic solution, which gives a blue coloration when oxidase is present and, in connection with hydrogen peroxide, a blue coloration when peroxidase is present.

While the test for oxidase and peroxidase in the stalk and ribs of leaves can be directly applied to the objects themselves, there is some difficulty encountered in the lamina, since the green color of the chlorophyll interferes with the recognition of the pure blue reaction.[2] Furthermore, when the juice is prepared by rubbing the leaf to a pulp and pressing this through flannel, it will contain so many chlorophyll granules in suspension that the juice has to be filtered through filter paper.

[1] Bumke and Wolffenstein have recently found that cellulose is comparatively easily changed, under certain conditions, hydralcellulose being formed. Perhaps a similar action takes place in the sweating leaf when too much moisture is present and the oxidizing enzyms act upon the cellulose walls.

[2] The blue reaction may be distinguished to some extent in the leaf by applying the reagent to the spongy tissue after the removal of the lower epidermis.

This filtering, however, proceeds so slowly that a brown coloration is meanwhile developed by oxidation. By mixing the juice, however, with an equal quantity of 90 per cent alcohol, or by rubbing the lamina in a mortar with an addition of 50 per cent alcohol—whereby proteins and other matters are precipitated—a larger amount of clear filtrate ready for the test is soon obtained.

It is often preferable to dry the leaf at a temperature of from 40° to 45° C., grind it to a fine powder, extract this for a short time with cold water, and apply the tests to the filtrate. It need hardly be mentioned that the juices of the pith or of the main ribs of the leaves can serve directly for the tests. They filter easily and do not darken as readily as the juices from the lamina.

In regard to the guaiac blue, it may be mentioned that it sometimes fades out soon after its formation. This may be due to tannin and other reducing compounds; it seems not to be due to another enzym.

ARE THE TOBACCO OXIDASE AND PEROXIDASE KINDS OF PROTEINS?

These enzyms belong neither to the coagulable albumins nor to the nucleoproteids. The latter are precipitated by dilute acids, but since the juice of green tobacco leaf is of moderate acid reaction, it can not contain ordinary nucleoproteids in solution. Even upon the addition of 1 per cent of acetic acid to the juice, no nucleoproteids are precipitated. If, as Spitzer has recently claimed, the peroxidase of mammalia is a nucleoproteid, we must assume a considerable difference between the peroxidase of mammalia and that of tobacco, and probably of other vegetal sources.

The following tests show, further, that oxidase and peroxidase do not belong to the coagulable albumins. The freshly expressed and filtered juice of the tobacco leaf yields upon heating to 54° C. a copious coagulum of albumin, while the filtrate therefrom gives a strong reaction for oxidase and peroxidase. On further heating this filtrate to 65° C. for a second, another but a very insignificant coagulation is observed. The filtrate of this precipitate still yields both reactions, but it may now be heated to the boiling point without giving a coagulum. Further, when green tobacco leaves are dried at a temperature of 50° C., pulverized, and extracted with ten times the weight of cold water for thirty minutes, a filtrate of weak acid reaction is obtained which contains mere traces of albumin. Nevertheless, it gives the peroxidase reaction with guaiac, even after heating for a second to 85° C. (not to 90° C.). This solution was heated for a few seconds to a temperature of 66° C. and the slight turbidity removed by filtration, after which the cooled filtrate was saturated with ammonium sulphate, whereby a dark precipitate was formed. This contained the oxidase and peroxidase and a part of the brown coloring matter of the original extract, while the filtrate yielded no trace of the guaiac reactions. After being freed as far as possible from the adhering liquor, by pressing between sheets of filter

paper, the precipitate was easily dissolved in water. This solution not only gave intense reactions for oxidase and peroxidase, but yielded also a precipitate with alcohol and gave Millon's reaction; the biuret reaction, however, was impeded by the dark color of the liquid. Both oxidase and peroxidase, therefore, seem to have the main character of albumoses. It follows, then, that the animal oxidase must differ from the vegetal, since Abelous and Biarnès believe the former to be a kind of globulin.[1] When the aqueous extract of dried tobacco leaves is neutralized, a small amount of precipitate is obtained, containing, among other things, lime salts, and a part of the oxidase mechanically carried down.

BEHAVIOR OF OXIDIZING ENZYMS TOWARD INJURIOUS COMPOUNDS.

The supposition might be entertained that oxidase and peroxidase are chemically closely related, the latter representing, perhaps, a derivative of the former. Peroxidase, however, resists not only a higher degree of heat than oxidase, but also is less easily injured by poisons.

In comparing tobacco oxidase with tobacco peroxidase in their behavior toward noxious compounds, a solution of the former was prepared in the manner formerly described,[2] and its reaction compared with the oxidase reaction in fresh tobacco juice after addition of various solutions of known strength.[3] Before making the tests care was taken to have a neutral or only slightly acid reaction, as guaiac blue is easily altered by various influences, and especially by mineral acids and alkalies. Also, certain organic substances of comparatively weak acid qualities, like tannin, can prevent the reaction. Acetic acid, in higher concentration than 2 per cent, interferes with the production of the guaiac blue.

The following table shows the results obtained:

| Reagent. | Oxidase. | Peroxidase. |
|---|---|---|
| Acetic acid, 3 per cent | Killed within 5 hours | Reaction much weaker after 24 hours. |
| Acetic acid, 1 per cent | Killed within 24 hours | Reaction weaker after 24 hours. |
| Hydrochloric acid, 0.5 per cent. | Killed immediately | Killed immediately. |
| Sulphur dioxide, 0.25 per cent. | do | Unchanged after 24 hours. |
| Ammonia, 0.3 per cent *a* | But little altered after 24 hours. | Unaltered after 48 hours. |
| Potassium hydroxide, 0.3 per cent. *a* | Considerably decreased after 2 days. | Do. |
| Free nicotine, 1 per cent | Killed in 24 hours | Do. |
| Formaldehyde, 5 per cent | do | Do. |

*a* In these cases the fresh juice was neutralized before adding the above percentage.

[1] Compt. Rend. Soc. Biol., vol. 49, p. 493.

[2] Report No. 59, U. S. Department of Agriculture, p. 29.

[3] A colorless solution of the tobacco oxidases can not be obtained from the lamina of the tobacco leaves, since the juice turns brown very soon, but it may be obtained from the midrib by grinding it, expressing the pulp, and filtering the liquid. By heating a moment to 65° C. (149° F.), the albuminous matters coagulate and a clear, colorless filtrate is obtained which turns yellow but slowly.

It may be added that ammonium oxalate (5 per cent) had no deleterious effect upon oxidase after two days; but nicotine tartrate in a 5 per cent solution, and quinine acetate in a 0.5 per cent solution, seemed to damage the oxidase after four days, although but very little.

KILLING TEMPERATURE OF OXIDIZING ENZYMS.

The temperatures thus far observed which render enzyms inactive are not constant under all conditions; the acidity of the plant juice, the degree of dilution, the duration of the heating, and the presence of certain salts have a modifying influence on the height of the temperature at which the change to the inactive modification takes place. It is to be regretted that authors have not always mentioned the conditions and the duration of the heating. The oxidase of the stalks of the sugar cane is killed at 60° C. (140° F.), the peroxidase of it at 95° C. (203° F.), according to Raciborski. Tyrosinase, an oxidase easily oxidizing tyrosine to a dark substance, is injured at 50° C. (122° F.) and killed below 70° C. (158° F.), according to Bertrand. Laccase, an oxidase of widespread occurrence, is killed at 63° C. (145.4° F.). Oenoxidase loses half of its oxidizing power at 72° C. (161.6° F.) within four minutes, and at 55° C. (131° F.) in one and one-half hours. The oxidase of mammalia is killed at from 80° to 85° C. (Abelous and Biarnès.)

The influence of the duration of the heating is shown by the following test. The killing temperature of the oxidase in the juice of the tobacco leaf was repeatedly found to be from 66° C. to 67° C. when the juice was diluted (one part dried leaf to twenty parts of water) and the solution heated for three minutes. But in heating it for a second only a much higher temperature may be endured. Certain salts, as ammonium sulphate, and also traces of free ammonia, increase the resistance, while acids, even in small quantities, decrease it. The juice of the midrib contains less acid than that of the lamina, and consequently it takes a temperature several degrees higher to kill the oxidase in the former than in the latter, but on being neutralized the latter may be safely heated for a moment to 75° C. The addition of alcohol decreases the power of resistance. Thus an addition of 33 per cent of alcohol to a neutralized solution of oxidase will depress the killing temperature about 2° C.

The following tests were made with peroxidase: Fresh tobacco leaves were ground, with the addition of some sand and a little water, and the pulp expressed. The residue was now left for some hours in contact with water to which 0.5 per cent acetic acid was added, and expressed again. The filtrate thus obtained was exactly neutralized with dilute caustic soda. It gave only a very faint reaction for oxidase, but an intense reaction for peroxidase. To one portion (20 c. c.) was added one-half its volume of absolute alcohol; to another 10 per cent of ammonium sulphate. Upon heating in a water bath it was found

that the peroxidase in the alcohol mixture was killed at a temperature of 70° kept up for a few seconds, while in the mixture containing the ammonium sulphate the enzym was not killed after heating the mixture for a short time to 93° C. In the control solution the enzym was killed at 87° C. after three minutes.

Grüss encountered in some vegetable objects an oxidase that resists the action of boiling absolute alcohol. He designates it as $\gamma$-oxidase.

That such an oxidizing enzym exists which can resist even boiling absolute alcohol might appear strange. But when we consider that the action of absolute alcohol consists in the first place of depriving the objects of water, and, further, that dried enzyms resist a much higher temperature than enzyms in the moist or dissolved state, that observation loses its singularity. It may here be pointed out that recent investigations of bacteriologists have proved that certain kinds of bacteria also succumb much more easily to alcohol of 50 per cent than to absolute alcohol. Protoplasm of a high density which can resist drying is much less accessible to poisonous actions when dry than when moist.[1] The writer has also observed that the oxidase in the tobacco leaf resists a higher temperature when the leaf is itself warmed with some absolute alcohol than when the dilute leaf juice is. However, a prolonged contact with absolute alcohol will doubtless kill the oxidase. Here, also, the peroxidase resists much better than the oxidase.

### CAN THE AMOUNT OF OXIDASE BE INCREASED BY SPECIFIC MANURING?

Since Bertrand and Villiers have found some manganese is a regular ash constituent of the oxidases[2] and since it seems justifiable to attribute to that circumstance an essential influence on the specific actions of the oxidases, it was of some interest to try to discover whether an increase of manganese in the soil would lead to an increase of the oxidizing enzyms in the tobacco plant. Therefore a 0.1 per mille solution of manganese sulphate was repeatedly used to water some tobacco plants, each of which received altogether 0.6 gram of that salt.[3] The examination of the ripe leaf, however, showed no noticeable increase of oxidase and peroxidase on colorimetric comparison with the plants not so treated. Possibly the soil contained a sufficient amount of manganese for the formation of the normal maximum amount of these enzyms.

### A THIRD OXIDIZING ENZYM IN THE TOBACCO PLANT.

The unfiltered juice of fresh tobacco leaves energetically decomposes hydrogen peroxide with evolution of oxygen. The clear filtrate

[1] Also seeds resist a higher temperature when dry than when soaked in water.

[2] Compt. Rend. vol. 124, pp. 1032, 1349, 1355.

[3] These experiments were conducted by Dr. E. H. Jenkins on the experimental field in Poquonock, Conn.

obtained from the turbid juice shows this property only to a very small degree while the suspended matter acts as powerfully as the unfiltered juice. It is easy to prove that neither particles of the living protoplasm of the leaf cells nor an admixture of bacteria are the cause of this action, since contact with chloroform does not essentially alter that power after a day. Certain observations of the writer, not agreeing with the prevalent views, led him to a further examination of this phenomenon. Several authors have observed this property with various organisms and ascribed it to the known enzyms contained in them, following Schoenbein,[1] who expressed this opinion in the year 1863.

This view was not even doubted after it was shown by Jacobson that this property of the common enzym preparations may be destroyed without injury to the true enzym nature, i. e., to the specific activity.[2]

While ptyalin, pepsin, and myrosin preparations gave Jacobson only small quantities of oxygen by decomposition of hydrogen peroxide, emulsin, pancreatin, and diastase, in freshly prepared condition, yielded considerable quantities. Jacobson proved that by heating to a certain temperature, by "exhaustion of the catalytic power" (of decomposing hydrogen peroxide), by dilute acids, and by various poisons, this property could be either destroyed or considerably weakened without the true enzym character being materially injured.

Since it seems very doubtful that the molecule of an enzym can be changed to a great extent without destroying the specific property, the writer finds it much more natural to explain the observations of Jacobson by the presence of another enzym, to which this decomposing action on hydrogen peroxide is due. In the preparations of the common enzyms the presence of other enzyms as impurities can not be surprising. The further observations of the writer have confirmed this view. A full account will be given later in a separate bulletin. Here it may suffice to sum up the main results:

1. The property of developing oxygen by decomposition of hydrogen peroxide is due to a separate enzym.

2. This enzym, to which the name catalase may be given, occurs in two modifications, one insoluble and one soluble in water. They may be distinguished as $\alpha$ and $\beta$ catalase. The insoluble or $\alpha$ catalase is probably a combination of the enzym with a nucleoproteid.

3. This enzym is killed at 72–75° C. (161–167° F.). It is an oxidizing enzym, since it easily produces quinone from hydroquinone. It does not produce guaiac blue from a tincture of guaiac, not even in the presence of some hydrogen peroxide; hence it differs essentially from the ordinary oxidase and peroxidase.

4. The insoluble modification is soluble in dilute alkaline liquids.

5. In the curing process of the tobacco leaf there is a small increase

[1] Journ. Pract. Chem. vol. 89, p. 326.

[2] Jacobson, Zeitsch. Physiol. Chem. vol. 16, p. 340, 1892.

of the soluble modification, probably formed from the insoluble. This increase is larger in the sweating process.

6. This enzym is the most durable of those in the tobacco leaf under ordinary circumstances, since it occurs in tobacco even over 6 years old, in which no trace of other enzyms, not even of the peroxidase, can be found.

7. It is certainly an important factor in the heating up of the tobacco pile, as recent experiments with fermenting tobacco have shown.

The general occurrence of this enzym in plant as well as in animal cells suffices to indicate a highly important physiological rôle. It is probably intimately connected with the process of respiration. The following two hypotheses as to its function appear the most probable to the writer:

1. Since many oxidative processes lead to the formation of hydrogen peroxide as a by-product, it is important that such a poisonous by-product be at once destroyed when accidentally formed in the cells in the course of the respiratory oxidations.

2. This enzym may have the office of loosening affinities in fatty acids and sugar in order not to tax the chemical energy of the protoplasm itself too heavily when these compounds are consumed for the purpose of respiration.

## REMARKS ON THE MOSAIC DISEASE OF THE TOBACCO PLANT.

The mosaic disease, in the Southern States called "frenching" and in the Northern States "calico," "brindle," and "mongrel" disease, is of special pathological interest. For a discussion of the causes, theories, and scientific investigations on the development of this disease the reader is referred to a special and extensive bulletin by Albert F. Woods, of this Division, which will make its appearance at no distant date. In this place will be mentioned chiefly a number of observations made by several planters.

The disease is easily recognized by the contrast of the dark-green regions, mostly near the veins, and the light-green regions of the lamina. The former, being better nourished on account of containing more chlorophyll than the latter, grow faster. This causes the leaves to curl and assume a wavy shape, like corrugated iron, rendering the leaves worthless for wrappers. Highly diseased leaves have to be entirely discarded. The disease sometimes affects as much as 10 per cent of the plants of an entire field. At times it attacks only a few leaves of a plant, and at other times the entire plant is affected. Broad-leaf tobacco is asserted to be more liable to the disease than Habana seed tobacco. The annual damage thus done in the United States is estimated to be more than a million dollars.

Various causes seem to create a tendency to the disease. Some act in the seed bed, some depend upon the mode of planting in the field,

and others seem to depend upon changes in the weather.[1] Solely a surplus amount of water in the soil, involving a deficiency of root aeration, does not produce the mosaic disease, as the writer observed. In a field one corner of which was continuously moist, the plants were of a uniformly yellowish-green all over, and they were only about half the height of the healthy plants, but there was no trace of symptoms of mosaic disease visible.

The diminished amount of chlorophyll in mosaic diseased plants, leading to a diminished production of organic matter, soon shows its effect in the more or less retarded development of the whole plant. There is also less coagulable albumin and less acid in the leaves of the diseased plants than in those of healthy ones of about equal age. The juices were titrated with one-tenth normal soda solution and the acid calculated as malic acid.

The following amounts of malic acid were found in a diseased and in a healthy plant:

| | Diseased plant. | Healthy plant. |
|---|---|---|
| | *Per cent.* | *Per cent.* |
| Pith | 0.033 | 0.033 |
| Midrib of leaf | .048 | .105 |
| Lamina of leaf *a* | .210 | .277 |

*a* After removal of midrib and large side ribs.

The relative amounts of oxidizing enzyms also are different in diseased and healthy leaves. The observations of the writer agree essentially with those of Woods.[2] Not only the midrib and the pith, but even the dead spots of the diseased leaves contain very much oxidase, while the lamina contains much more peroxidase than that of healthy leaves. The writer had occasion to observe tobacco fields, just before harvesting time, in Connecticut and Massachusetts, and was surprised at the great differences in the extent of the disease even on neighboring fields. Some planters entertain the belief that a too extensive use of mineral fertilizers favors the disease, and, indeed, those fields had the least number of diseased plants which had received chiefly organic manure. Mr. Du Bon, of Poquonock, Conn., whose crop of Habana

[1] One cause may be an insufficient distribution of the manuring material. A tobacco grower at Poquonock set his plants in a field in which one inch of earth covered the cotton-seed meal employed as manure, the latter not being uniformly mixed with the earth. On further development more than 50 per cent proved calico plants.

[2] Paper read before the American Association for the Advancement of Science at Columbus, Ohio, August, 1899. Other papers on this disease have been published by Dr. Wm. C. Sturgis, Conn. Agr. Exp. Sta. Report for 1898; further by Adolf Mayer, Landw. Vers. Stat., vol. 32 (1886); by Beijerinck, and by Iwanowski, Centr. Bakt., vol. 5.

seed tobacco was in excellent condition, had applied per acre the following amounts of fertilizers in the drill:

5 cart loads horse manure,
20 hundredweight of cotton-seed meal,
500 pounds of "dissolved bone black,"
500 pounds cotton-hull ashes, and every other year
300 pounds of lime.

On a field near East Hartford, Conn., many more calico plants were to be seen than on another field on the opposite side of the road—on the former about 8 to 10 per cent, on the latter only about 3 to 4 per cent. This difference might be ascribed to differently manured seed beds or to the different manuring in the field. Both farmers applied horse manure—the first, 5 cart loads to the acre; the second, 9 cart loads to the acre. The former also used 10 hundredweight of bone dust, while the latter applied 800 pounds per acre of the following mixture:

150 pounds of ammonium sulphate,
450 pounds of potassium sulphate,
640 pounds pulverized bone and meat,
600 pounds of "dissolved bone black."

The latter had therefore applied not only much more horse manure to his field, but also more of the easily accessible phosphoric acid and more potash than the former.[1]

Mr. Du Bon, a good observer, reported to the writer the following:

The calico disease may appear even in the seed bed, especially when it is too rich in nitrogenous manure, but the first two or three leaves of the attacked plants are generally normal. Fresh soil that has never served for raising crops does not produce the disease in the seed bed nor does an excess of moisture, but too high temperature is likely to produce it. Yellow plants, stunted in the seed bed by cold weather, never show mosaic disease in the field. In one case it was observed that an acre and a half planted with such yellow plants did not show a single calico plant, while the neighboring acres, planted with vigorous seedlings, developed a great many. Very vigorous plants that had been manured heavily with castor pomace and were looking very well showed much calico later on.

The disease is not easily propagated through the soil of the field. Even twin plants may be found where one is much attacked and the other bears hardly a trace of the disease.[2] Near Poquonock fields have been used for twenty-five years uninterruptedly for the culture of tobacco, and upon this land thoroughly healthy crops are now produced, although formerly the disease was often observed. One year, on a piece of land that contained 12,000 plants, 3,200 calico plants were cut out with a hoe when the plants had reached about 2 feet in height. The following year hardly half a dozen calico plants were noticed on that same plot, but these plants came from a seed bed containing new soil. The great influence of the growth in the seed bed on the

[1] Koning (Zeitschrift für Pflanzenkrankheiten, 1899, p. 65) asserts that manuring with kainit and Thomas phosphate diminishes the extent of the disease.

[2] This fact seems to be in contradiction to the behavior of the plants in the seed beds. A satisfactory explanation is wanting.

later development of the disease is shown by the following observation of Mr. Du Bon: "It happened once that in a portion of a field every other plant was a calico plant and the alternating ones were healthy plants. This remarkable circumstance found its explanation in the fact that in the process of machine planting two baskets were used containing the plants of two different seed beds, one bed being in a condition to favor the disease, the other containing new soil. Two planters worked here at the same time. The neglect of proper precaution in taking the young plants from the seed bed may create a tendency to the disease." In this connection Mr. Barnes, of Hatfield, Mass., related the following: "Young plants were taken from the same seed bed by two different farmers, and, although the soil of the fields was the same, one farmer had many calico plants in his field and the other had almost none. Inquiry revealed the fact that one farmer took the plants from the seed bed when it was quite dry, the other when it was well moistened. In taking the plants from a dry bed one can not help lacerating the roots, while from a well-moistened bed the roots may be withdrawn in an almost intact condition. Lacerated roots do not generally develop again to such a vigorous state as is required by the quickly growing tobacco plants."

For the prevention or diminution of the disease, Mr. Du Bon recommends keeping the plants in the seed bed not too warm and also changing the seed bed. Beds that produce the disease might be grown over for one year with grass, in order to put them in proper condition for the production of healthy tobacco plants. While many planters seem convinced that the diseased plants can not recover, others claim that by hoeing and stirring the soil well the disease may be cured in the initial stage. Mr. Barnes, of Hatfield, Mass., claims to cure the disease by lifting the whole plant a little from the ground. In both cases a better aeration of the soil is reached. The writer is not prepared to confirm or contradict these statements.

## OBSERVATIONS ON CURING.[1]

### INTRODUCTION.

The curing period is a time of continuous anxiety for the tobacco planter. Too dry weather stops all changes in the leaves, particularly the development of the proper color, while too moist weather, especially at a temperature above 24° C. (75° F.), favors the disastrous pole burn. The great desire of the tobacco planter to become entirely independent of the weather by such improvements in the barn construction as will permit the proper regulation of the temperature and moisture is therefore reasonable.

The general introduction of an ideal tobacco barn can be only a question of time. If the tobacco is becoming too dry, steam should be turned into the building; and if it is becoming too moist, dry heat

[1] These observations were made with leaf cured on the stalk.

should be applied. An agricultural journal describes such a barn as follows:

The barn is what is called a "three-bent" shed. There are three rows of beams, one through the center and one on either side. A 2-inch steam pipe follows the outside beams around the shed. This is believed to be sufficient to supply the necessary heat to the whole building. The tobacco in the extreme outside of the shed rarely suffers from the pole sweat. The tobacco through the center, and especially that low down, is always the worst affected, and the pipes are arranged to throw the most heat into that part of the building. If the experiment proves a success in preventing pole sweat, the time is soon coming when artificial heat will be used entirely in curing tobacco, for the even temperature and moisture that can be obtained are just what is needed for a perfect cure.

As the curing proceeds an alternating change from the moist to the dry condition of the leaves takes place, according to the atmospheric conditions. Practical experience has proved that a frequent change of this kind is desirable.[1] This agrees also with the theoretical inference. There is more oxidase in the ribs than in the mesophyll, and by the alternate drying and moistening the evaporation from the surface causes a current of juice to pass from the ribs to the mesophyll cells. This migrating juice finally distributes most of the oxidase from the bundle sheath and sieve tissue uniformly through the leaf. It is therefore desirable to have the ribs keep alive much longer[2] than the rest of the leaves, since dead and dry ribs would not support the process indicated.

As long as all the cells of a leaf are alive a current of organic matter—especially sugar, and also to a small degree, amido compounds—takes the opposite direction, namely, from the lamina to the ribs. Gradually this function stops, since a state of starvation sets in when the starch, in the form of sugar, has been transported to the stalk and consumed by respiration. The decrease of soluble albumin in the curing process is much slower than the decrease of starch. Even after a fortnight a moderate amount is left, and with single cured leaves, even after four weeks, some traces of it were found in the tissues.

### DECREASE OF ACIDITY.

It is an interesting fact that the acid reaction decreases in the lamina as the curing proceeds, as shown by the following table. For 200 sq. cm. there was required the following amounts of one-tenth normal soda solution:

| Date. | Uppermost leaves. | Lower leaves. |
|---|---|---|
| | c. c. | c. c. |
| August 1 | 3.8 | 3.0 |
| August 8 | 3.3 | 2.3 |
| August 14 | 2.5 | 1.8 |
| September 26 | 1.7 | .9 |

[1] Report No. 62 (p. 12), U. S. Department of Agriculture, by Marcus L. Floyd. This report also contains views on the best construction of the usual barns.

[2] The midrib may remain alive for three weeks and over.

At the end of the curing process the amount of free acid for a given surface was therefore reduced considerably.[1] A portion of the acid may have passed into the stalk, another portion may have been completely oxidized, and another may have been neutralized by ammonia formed in the destructive action of oxidizing enzyms on nitrogenous compounds. In the subsequent sweating process the liberation of ammonia is more energetic, and neutralizes the rest of the acid. The decrease of acidity in the curing process is of practical importance, since the following sweating process will set in with sufficient energy only when the reaction is nearly neutral. The practice of the tobacco manufacturers in Florida of applying a spray of ammonium carbonate solution when the "heaps will not heat up well" is therefore in accordance with the scientific inference.

### BEHAVIOR OF THE OXIDIZING ENZYMS IN THE CURING PROCESS.

In a normally conducted curing process, whether curing single leaves or curing on stalk, the oxidase and peroxidase are well preserved. This is not the case under conditions unfavorable to a normal curing. The oxidase especially loses its active character more or less. Flue curing seems just as injurious[2] as prolonged moist weather. The acidity in the leaves is, according to the writer's observation, generally too weak to cause injury; but the occasional entrance of too much sunlight into the barn may diminish the oxidase in the exposed leaves. Reynolds Green, and Brown and Morris have shown that enzyms, as, for example, diastase, are injured by exposure to direct sunlight, while with regard to the action of water it has been shown by Laborde that a gradual destruction of oenoxidase takes place within twelve days by self-oxidation when it is dissolved in water and exposed to air. There can hardly be any doubt that much water retained for a certain time in the curing leaves of the barn will favor self-oxidation of the tobacco oxidase. This is also shown by the following test.

A large upper leaf was placed in a covered glass cylinder containing some water, to insure an atmosphere saturated with water vapor. After being kept in darkness for a week at from 22° to 28° C., comparison with a normal leaf showed less oxidase in the parenchyma of the leaves so treated than in that of equally old fresh leaves of the same plant, while with the veins the difference was not so marked. On the other hand, no decided decrease of peroxidase could be noticed.

[1] In the pith and bark no decrease of acidity, but, on the contrary, a slight increase was observed during the first two weeks of curing. Further it may be mentioned that the acidity seems to decrease more slowly when the leaves are single cured than when cured on stalk. Only one test was made, however, in regard to this.

[2] Flue curing is mainly used in the curing of the bright yellow tobacco of Virginia, Tennessee, and North and South Carolina. The temperature reached thereby—71–79° C. (160–175° F.)—is detrimental to the oxidase. Such tobacco, however, is not subjected to sweating.

Furthermore, according to Mr. Marcus L. Floyd, it is a known fact that tobacco too long "in case" because of prolonged moist weather will sweat but very imperfectly. The poorly sweated crop of 1898 in Connecticut also showed much "canker" and "pole burn," conditions favored by too moist weather.

When it happens that tobacco does not sweat well, or even not at all, it may be too acid or may have lost its oxidizing enzyms through irregularities in the curing barn, or it may be too poor in the proper oxidizable material. The writer was assured by tobacco growers of Connecticut and Massachussetts that tobacco grown in very dry years is incapable of sweating; 1871 was such a year. Even the transportation of the tobacco to the West Indies and back, an experiment tried by Mr. Barnes, of Hatfield, Mass., to enforce a natural sweat, did not change the rank smell of the cured to the aromatic odor of sweated tobacco.

The writer was informed in Lancaster, Pa., that the crop raised there in 1881 required nine years to reach the proper quality by means of the natural sweat. Here probably a gradual oxidation without oxidases has produced finally a result similar to that reached in a short time in presence of the oxidizing enzyms.

Since it is the energetic oxidation in the sweating process that yields a cigar leaf of superior quality, it must form one of the principal aims of a tobacco farmer to preserve the oxidizing enzyms while the tobacco is curing in the barn. In the process of sweating, however, there is generally a gradual decrease of oxidizing enzyms going on, the high temperature favoring not only the action of these enzyms on oxidizable material, but also the oxidation of the enzyms themselves. Practical experience long ago found it necessary to take apart and rebuild the fermenting piles as soon as the temperature reached about 60° C. (140° F.). Indeed, if the temperature be allowed to rise much higher there would be a rapid decrease of oxidase, and all the improvements hoped for would come to a premature end.[1] The relative amount of water in the fermenting piles or cases will also exert an influence. The peroxidase suffers less than the oxidase, but the former is probably of very much less importance than the latter in the sweating process. Investigations on this point will be carried on at some later time when occasion offers.

## TESTS FOR OXIDASE AND PEROXIDASE IN CURED AND FERMENTED TOBACCO.

In regard to the tests for these enzyms it must be pointed out that from the absence of oxidase in a tested sample it does not necessarily follow that all of the leaves from the same curing barn would be

[1] A full account of the temperature changes in fermenting piles of cigar leaf tobacco is given in Report No. 60, U. S. Department of Agriculture, by Milton Whitney and Thomas H. Means.

devoid of it. It may be that the leaves tested came from near a barn door which was perhaps frequently opened, thus freely permitting the destructive action of the sunlight. Therefore in controlling a curing crop in the barn leaves should be tested not only from near the wall, but also from the more central part of the barn.

The test was at first made in the following manner: The tobacco leaf was deprived of the large ribs, and after drying at a temperature of 40° C. (104° F.) was very finely pulverized. One gram of this dry powder was mixed with 20 c. c. of water and left to stand for five hours in an Erlenmeyer flask at the ordinary temperature. To 10 c. c. of the filtrate a few drops of an alcoholic solution of guaiac resin were added and the mixture was left to stand for ten minutes, with moderate shaking. A blue coloration indicated the presence of oxidase. Since, however, the brown color of the tobacco extract is often so dark that it interferes with the recognition of a weak blue reaction, it was found preferable in such cases to pour guaiac tincture cautiously on the surface of the tobacco extract, avoiding a thorough mixing. The blue color will soon appear as a ring on the surface of contact of both liquids. If, however, no blue coloration appears, a few drops of peroxide of hydrogen are added. A blue coloration in this case is due to the presence of peroxidase. In order to test for the peroxidase in presence of the oxidase in the tobacco extract, it is necessary to heat the liquid for three minutes to 70° C. (158° F.) in order to first kill the oxidase before the test for the peroxidase is made. Guaiac solution in presence of peroxide of hydrogen is now left to act on the cooled solution. The blue reaction for peroxidase sets in at once.

Some additional remarks may be made on the tests with guaiac resin. A solution of guaiacum resin is prepared by dissolving at the ordinary temperature 2 grams in 100 c. c. of absolute alcohol. This tincture must be kept cool and in the dark, and be renewed from time to time, since the active principle, the guaiaconic acid, is otherwise gradually oxidized. Old tincture will soon turn bluish on addition of hydrogen peroxide alone. Attention must be paid to the reaction of the liquid to be tested, which must not be alkaline but neutral or slightly acid, and also to the quality of the resin, since worthless kinds exist in the market. A normal resin must yield an intense blue color with highly dilute nitrous acid. Only the interior parts of transparent pieces of guaiacum resin should be selected for preparing the tincture of guaiac. It is of no particular advantage to use the guaiaconic acid, instead of the resin itself.

An attempt has been made to disqualify guaiacum resin as a reagent for oxidizing enzyms on the ground that nitrous acid, ferric chloride, and other oxidizing mineral compounds also yield a blue reaction. Such objections are groundless when fresh organized tissues are under investigation. Other oxidizing influences are easily recognized by control tests, which the careful worker will not omit to make. The

assertion that albumin and gelatin give the reaction is erroneous. On the contrary, egg albumen impedes or prevents the oxidase reaction on guaiacum, as does also much tannin. It may be added here that among other substances silver nitrate also yields a blue coloration, especially in presence of a very small amount of ammonia. Such blue reactions are not restricted to certain limits of temperature as the reactions of oxidizing enzyms are.

Still more attention to control tests must be paid when materials which are not fresh are to be tested; for, while the fresh tobacco leaf never contains nitrites, sweated tobacco may contain them. This must be considered when the tests are made with sweated tobacco. (See on this point also page 55 of this report.)

The following tests were made with samples, not collected personally, but received by mail.

*Tobacco cured but not sweated.*

A.—SAMPLES FROM MARYLAND.

[The samples were grown in 1898 on the farm of the Maryland Agricultural Experiment Station. Only the last mentioned was from another locality.]

| Date. | Sample. | Oxidase. | Peroxidase. | Remarks. |
|---|---|---|---|---|
| 1899. | | | | |
| Mar. 13 | Connecticut seed leaf.... | | | |
| | (a) Lowland plot ..... | None ..... | Moderate ..... | |
| | (b) Upland plot ..... | .....do ..... | Trace ..... | |
| 13 | Habana seed ..... | Moderate ..... | Much..... | Cured without artificial heat. |
| 13 | Sumatra seed ..... | Less than Habana.. | ..... | |
| 13 | Vuelta ..... | None ..... | Much..... | |
| 13 | Pardidos ..... | Moderate ..... | .....do ..... | |
| 18 | Maryland broad leaf..... | Slight ..... | Moderate ..... | All subjected to the flue-curing process. |
| 18 | Virginia ..... | Moderate ..... | Intense ..... | |
| 18 | Sumatra seed ..... | None ..... | Moderate ..... | |
| 18 | Connecticut broad leaf... | .....do ..... | Trace..... | |
| 18 | Habana seed ..... | .....do ..... | Moderate ..... | |
| 18 | Pardidos ..... | .....do ..... | .....do ..... | |
| Apr. 4 | Maryland tobacco ..... | .....do ..... | .....do ..... | |

B.—SAMPLES FROM KENTUCKY. (CROP OF 1898.)

| | | | | |
|---|---|---|---|---|
| Mar. 13 | White burley lugs..... | None ..... | Moderate ..... | Single-leaf cured. |
| 13 | .....do ..... | Moderate ..... | Much..... | Cured on stalk. |
| 20 | Burley grade red leaf.... | None ..... | Little..... | Do. |

C.—SAMPLES FROM PENNSYLVANIA. (CROP OF 1898.)

| | | | | |
|---|---|---|---|---|
| Mar. 20 | Pennsylvania Habana seed. | Moderate ..... | Much..... | Seed wrapper. |
| 20 | Habana seed ..... | Trace..... | Moderate ..... | Seed filler. |
| 20 | Pennsylvania seed leaf.. | Moderate ..... | .....do ..... | Wrapper. |
| 20 | Seed leaf..... | .....do ..... | .....do ..... | Filler. |

*Tobacco cured but not sweated*—Continued.

MISCELLANEOUS SAMPLES.

| Date. | Sample. | Oxidase. | Peroxidase. | Remarks. |
|---|---|---|---|---|
| 1899. | | | | |
| Feb. 22 | Wisconsin tobacco (Soldiers' Grove). | None | None | |
| 24 | Florida Habana seed (Quincy). | Much | Much | Crop of 1898. |
| Aug. 13 | Hatfield, Mass | do | do | Single-leaf cured (1898). |
| Sept. 23 | Poquonock, Conn | do | do | 1899 crop, stalk cured. |
| Oct. 20 | Ada, Tex | None | Trace | 1899 crop. This sample had white veins. |
| 20 | do | do | Moderate | This tobacco was cut after being "drowned or scalded," *a* and was stripped before it was completely cured. |
| Dec. 12 | Raleigh, N. C | do | Trace | Was flue cured; crop of 1899. |
| Oct. 18 | Elmira, N. Y | Moderate | Much | Medium weight and color; cigar type; crop of 1899. |
| 18 | do | do | do | Dark, heavy; cigar type. |
| 18 | do | Trace | do | Light weight and color; cigar type. |
| 18 | Virginia | Little | do | Dark, heavy; plug type. |
| 18 | do | do | Moderate | Medium dark; crop of 1899. |
| 18 | do | Trace | Much | Light weight, dark. |

*a* This drowned or scalded state is produced when after several days' heavy rain very warm and sunny days follow; the leaves soon wilt.

*Tobacco, cured and sweated.*

A.—SAMPLES FROM KENTUCKY. (CROP OF 1898.)

| Date. | Sample. | Oxidase. | Peroxidase. | Remarks. |
|---|---|---|---|---|
| 1899. | | | | |
| Mar. 7 | Tobacco from Hopkinsville, Ky. | None | Trace | New-ground tobacco; planted May 14; cut Aug. 10; fired lightly; bulked Nov. 21. |
| 7 | do | Slight trace | Moderate | New-ground tobacco; fired heavily, bulked later. |
| 7 | do | do | Much | Old-ground tobacco; fired heavily; bulked Dec. 10. |
| 7 | do | do | do | Same as former, but bulked later. |

B.—SAMPLES FROM OHIO. (CROP OF 1898.)

| | | | | |
|---|---|---|---|---|
| 1899. | | | | |
| Sept. 24 | Zimmer Spanish | None | Trace | |
| 24 | do | do | Moderate | |

C.—SAMPLES FROM CONNECTICUT. (CROP OF 1898.) *a*

| | | | | |
|---|---|---|---|---|
| 1899. | | | | |
| Sept. 21 | Gastonbury broadleaf | None | None | Light wrappers. |
| 21 | South Windsor broadleaf. | do | Much | Do. |
| 21 | East Windsor Hill broadleaf | do | Trace | Do. |
| 21 | South Windsor broadleaf. | do | Much | Dark wrappers. |
| 21 | Windsor Habana seed | do | Moderate | Do. |
| 21 | Portland Habana seed | do | Much | Do. |
| 21 | Poquonock, Conn., Habana seed. | Moderate | do | Passed through the natural sweat. |

*a* One sample of 1893 crop, grown at Canton, Conn., showed no trace of oxidase or peroxidase.

*Tobacco, cured and sweated*—Continued.

MISCELLANEOUS SAMPLES.

| Date. | Sample. | Oxidase. | Peroxidase. | Remarks. |
|---|---|---|---|---|
| 1899. | | | | |
| Mar. 4 | Maryland tobacco, Jewell | None | | 1898 crop. |
| 4 | Virginia | do | | Flue cured; 1896 crop. |
| Sept. 25 | Wisconsin | do | | 1897 crop. |
| 25 | Lititz, Pa., broadleaf | do | | 1893 crop. |
| 25 | Lititz, Pa., Habana seed | do | Trace | 1897 crop. |
| 25 | Hatfield, Mass., broad-leaf. | Moderate | Much | 1898 crop, single-leaf cured. |
| Nov. 1 | Ohio Zimmer Spanish | None | None | Stalk cured, crop of 1898, from Ohio. |
| | Ohio Little Dutch | do | Much | From Ohio. |
| Aug. 18 | Hatfield, Mass., Habana seed long wrappers. | Much | do | Single-leaf cured and sweated in cases at 100° F. 1898. |
| 18 | Hatfield, Mass., suckers. | Moderate | do | Do. |
| 18 | Hatfield, Mass., top of suckers. | do | Moderate | Do. |
| 18 | Hatfield, Mass., ground leaves. | Little | do | Do. |
| Dec. — | Remedios, Cuba | None | Much | Crop of 1899. |
| | Pardido, Cuba | do | Slight trace | Do. |
| | Haiti | Trace | Much | Do. |
| | Puerto Rico | None | Moderate | Poor grade, 1899. |
| | Puerto Rico | do | do | Best grade. |

We learn from these tables that the flue-curing process is unfavorable for the preservation of the oxidizing enzyms, and that sweated tobacco has frequently lost its entire content of oxidase, while the peroxidase is more resistant under the conditions of the sweating process. From the absence of oxidase in fermented leaves no conclusion can, of course, be drawn as to its amount before the sweating was begun. The more intensely the sweating process is carried on, the more of these oxydizing enzyms will be destroyed.

## TEST FOR CATALASE IN VARIOUS TOBACCOS.

With regard to catalase, the third oxidizing enzym of tobacco mentioned above (page 22), some experiments were made on various samples of cured and sweated tobacco to determine the amount of oxygen developed by it from hydrogen peroxide in from fifteen to forty minutes. From the energy of this action inference may be drawn as to the relatively larger or smaller quantity of the enzym in different samples. Tobaccos that had been fire-cured, as the plug tobaccos, contain in most cases neither oxidase, peroxidase, nor catalase. Such samples examined were bright yellow Virginia, black African, and English olive-green leaf. A sample of Burley tobacco showed, however, slight traces of peroxidase and catalase. Since the temperature in this curing method often rises as high as 82° C. (180° F.) these observations do not surprise us. Also a flue-cured sample of yellow tobacco from North Carolina did not show traces of the three enzyms. Such tobaccos are not intended for cigars and are not submitted to the sweating process, hence the absence of the oxidizing enzyms is here not of any conse-

quence. But there are also conditions in the usual treatment of cigar tobacco which may injure the catalase. Thus no trace of it was found in one sample of sweated tobacco from Connecticut of 1897. In most cases, however, catalase is retained in the sweated cigar tobacco for a much longer time than either oxidase or peroxidase.

The comparative tests for $\alpha$ and $\beta$ catalase were carried out in the following way: The air-dried samples were very finely powdered after removal of the midrib. After remaining twenty-four hours in an exsiccator 2 grams were extracted for five hours with 40 c. c. of water at the ordinary temperature with frequent shaking, and then filtered through filter paper. Twenty cubic centimeters of the filtrate were mixed with 5 c. c. of neutralized commercial hydrogen peroxide. The development of oxygen by the soluble or $\beta$-catalase commences a few seconds after mixing. Then the extracted tobacco powder was, after washing, suspended in 30 c. c. of water and 10 c. c. of hydrogen peroxide added. The oxygen here developed was due to the action of the insoluble or $\alpha$ catalase. The proportion of the developed oxygen gradually decreased in all cases after a short time, since the hydrogen peroxide in the concentration applied oxidized and killed the enzym rather soon. The reaction was promoted by moderately shaking the flask.

In those cases in which after a rapid development of oxygen gas an early stop was noticed a second dose of hydrogen peroxide was added, which was repeated as often as found necessary until the reaction had been carried on for a given time.

It will be noted from the method of testing just described that the data relating to $\beta$-catalase are obtained from 1 gram of tobacco; those relating to $\alpha$-catalase from 2 grams.

Thus far no data are known that would enable us to calculate the absolute weight of catalase from a certain volume of oxygen developed in a given time by the decomposition of hydrogen peroxide. But quite generally we might make the following distinction as to relative quantities. The amount of $\alpha$-catalase is small when under the above-described conditions less than 50 c. c. oxygen are developed in fifteen minutes by 2 grams of tobacco; it is moderate when between 50 and 200 c. c. are developed, and high when the volume rises above 200 c. c.

As to $\beta$-catalase the amount may be called small when less than 20 c. c. of oxygen are developed in fifteen minutes by 1 gram of tobacco; moderate, at 20 to 100 c. c., and high, when the volume rises above 100.

| Sample. | Oxygen developed. Time of development. | By α-catalase. | By β-catalase. | Oxidase. | Peroxidase. | Remarks. |
|---|---|---|---|---|---|---|
| | *Minutes.* | *c. c.* | *c. c.* | | | |
| Connecticut broad-leaf. | 5 | 22 | 1.0 | | | Cured, 1899, but not sweated. |
| | 10 | 34 | 1.8 | Moderate. | Much.... | |
| | 15 | 42 | 2.0 | | | |
| | 30 | 66 | 2.0 | | | |
| Florida, 1897..... | 5 | 32 | 13.0 | | Some .... | Sweated in bulk. |
| | 10 | 45 | 19.4 | None .... | | |
| | 15 | 76 | 26.5 | | | |
| | 20 | 84 | 29.0 | | | |
| | 40 | | 36.8 | | | |
| Maryland smoker, 1898. | 5 | 12 | 8.2 | | | Light-colored, thin leaf, sweated slightly in bulk. |
| | 10 | 22 | 11.8 | | | |
| | 15 | 28 | 13.2 | None ..... | None .... | |
| | 30 | 36 | | | | |
| Ohio Zimmer Spanish | 5 | 108 | 17.1 | | | Crop of 1897, sweated in bulk. |
| | 10 | 174 | 32.0 | None ..... | Trace.... | |
| | 15 | | 40.5 | | | |
| | 20 | | 45.2 | | | |
| Wisconsin, crop of 1897, "Gummy" leaves. | 5 | 28 | 1.0 | None ..... | None .... | Natural sweat. |
| | 10 | 40 | 1.7 | | | |
| | 15 | 46 | 1.9 | | | |
| | 20 | 49 | | | | |
| Pennsylvania ..... | 5 | 32 | 4.2 | | | Passed through the "natural" sweat, 1898 crop. |
| | 10 | 50 | | None ..... | Moderate. | |
| | 15 | 67 | | | | |
| | 20 | 76 | 16.3 | | | |
| | 30 | 86 | | | | |
| | 40 | 89 | | | | |
| Remedios, Cuba..... | 5 | 27 | 3.2 | | | Sweated, 1899. |
| | 10 | 44 | 6.1 | None ..... | Much.... | |
| | 15 | 60 | 7.5 | | | |
| | 20 | 71 | 8.0 | | | |
| Pardido district, Cuba | 5 | 14 | 8.2 | | | Sweated, 1898. |
| | 10 | 20 | 11.0 | None ..... | Trace.... | |
| | 15 | 24 | 14.0 | | | |
| | 20 | 27 | 15.1 | | | |
| | 40 | 36 | | | | |
| Puerto Rico..... | 5 | 16 | 3.5 | | | Sweated, 1899. |
| | 10 | 20 | 4.4 | | | |
| | 15 | 25 | 5.1 | None ..... | Little.... | |

It was thought that it would also be of interest to test cigars of commerce for oxidizing enzyms. Of the samples procured, which were probably ot very different ages, not one contained oxidase or peroxidase, but catalase was present in all, although the amount differed considerably to judge from the energy with which hydrogen peroxide was decomposed. As to cigarette tobacco, five different brands of cigarettes were examined, viz, Old Dominion, Sweet Caporal, Gold Leaf, Chesterfield, and Egyptian Prettiest, but only in the last named was any catalase found.

*Oxygen developed in fifteen minutes.*

| Cigar samples. | Price. | By α-catalase. | By β-catalase. |
|---|---|---|---|
| | | *c. c.* | *c. c.* |
| Arena | 3 for 5 cents | 91 | 5.5 |
| Haranetta | 2 for 5 cents | 520 | 41.0 |
| Marquis L | 5 cents | 71 | 13.2 |
| Lucke Rolled | | 41 | 18.0 |
| Union Glory | 5 cents | 85 | 8.0 |
| La Valiar | 10 cents | 26 | 3.0 |
| Herbert Spencer | do | 273 | 29.5 |
| General Arthur | do | 304 | 13.3 |
| No name | 2 cents a piece | 61 | 8.5 |
| Do | 5 cents a piece | 102 | 17.5 |
| Do | do | 108 | 8.2 |
| Do | do | 32 | 3.8 |
| Do | | 241 | 55.0 |
| tian cigarettes | | 36 | 2.0 |

It will be noticed from this table that there is no direct relation between the commercial value of a tobacco sample and its catalase content. On the one hand, however, it may be said that a comparatively high content of soluble or $\beta$-catalase would be indicative of this tobacco having been subjected to a sweating at a higher temperature, since the ammonia developed renders some catalase soluble. Further, since a thorough sweat is essential for the development of aroma, a high content of soluble or $\beta$-catalase would indicate an improved aroma, other things being equal. On the other hand, it might be inferred that a sample containing very little soluble, but comparatively much insoluble catalase (see No. 11 of the above table), has passed only through the natural sweat and could be improved by a subjection to sweating in bulk after petuning with a very diluted solution of ammonium carbonate.

In order to reach a reliable estimate of the extent of the transformation of the insoluble into the soluble catalase by the sweat only leaves of equal age and very similar to each other should serve for comparison. A cured leaf can not be compared with a sweated leaf of the same crop when the former happens to be a lower or sand leaf and the latter an upper leaf. Neither can thin, strawy leaves be compared with gummy leaves, since the differences between these are very great in regard to their enzym content. Thus, a not sweated, very thin, probably a sand leaf, yielded in fifteen minutes by the above test 7.7 c. c. oxygen for the soluble enzym and 69 c. c. for the insoluble, while a sweated, gummy leaf of the same crop yielded 147 c. c. and 360 c. c. oxygen, respectively. There can be no doubt, however, that the above tests, judiciously carried out, may prove of practical value in certain cases

In order to obtain comparable results, and to eliminate the factor of individual differences, upper leaves which can be distinguished by their heavier body were picked out of a lot of cured leaves and of a lot of leaves sweated in bulk, of the same crop.[1] After moistening them a little they were left over night until they became pliable, whereupon they were spread out and the adhering sand carefully brushed off. The central portions of 12 leaves were then deprived of the midrib, and after drying at 40° C. (104° F.)[2] finely pulverized. Two grams each of this powder were weighed out, and the tests carried out as above mentioned. The result was as follows:

*Oxygen developed in thirty minutes.*

| | By $\alpha$-catalase. | By $\beta$-catalase. |
|---|---|---|
| | c. c. | c. c. |
| Cured but not sweated, filler leaves | 158 | 16.5 |
| Cured and sweated, filler leaves | 634 | 236.0 |
| Proportions of the volumes of oxygen | 1:4 | 1:14.3 |

[1] This tobacco, raised in 1899, came from the Experimental Farm of the Conn. Expt. Sta. in Poquonock, Conn. The curing was there supported by a carefnl application of artificial heat, and supervised by Dr. E. H. Jenkins.

[2] Tobacco kept at that temperature in a drying box does not become compl dry—still retains 4 to 5 per cent moisture.

We notice from these figures not only an enormous increase of $\beta$-catalase, but also a considerable increase of $\alpha$-catalase. It had been observed twice before by the writer that the $\alpha$-catalase also was increased in the sweated sample as compared with the cured sample. He ascribed this circumstance to accidental differences in the leaf character. But this supposition has to be abandoned in view of the above figures obtained from average samples. The only explanation the writer can offer that seems probable is, that there exists in the case of catalase, as with many other enzyms, a zymogen in the leaves, which, under the conditions brought about in the sweating process, is converted into the $\alpha$-catalase enzym itself.[1]

The relative intensity of the fermentation, or sweating, has also a decided influence upon the amount of $\beta$-catalase. Thus, upper leaves moderately sweated for wrapper purposes contain less than upper leaves heavily sweated for filler purposes. The amount of oxygen developed in thirty minutes by $\beta$-catalase was observed with the sample of the former to be 186 c. c., of the latter, however, 236 c. c. (both of the same crop). The difference in the amount of oxygen developed in thirty minutes in both cases by $\alpha$-catalase was but small, 619 and 634 c. c. oxygen, respectively.

In order to decide whether the petuning liquid[2] which was applied for the filler leaves, but not for the wrapper leaves, had contributed to the increase of the amount of catalase, 20 c. c. of that liquid were, after neutralization, mixed with 20 c. c. of water and 5 c. c. commercial hydrogen peroxide. The total amount of oxygen developed in thirty minutes was but 26 c. c. Since the amount of the petuning liquid applied was only 0.66 per cent of the weight of the tobacco, not more than 0.02 c. c. of oxygen gas would have been developed in thirty minutes by the amount of petune contained in 2 grams of tobacco applied for the test on catalase, an amount so small that it can be neglected.

## DEVELOPMENT OF THE "GRAIN" OF THE TOBACCO LEAF.

The "grain" means to the tobacco manufacturer small points plainly visible on the extended leaves after the curing or after the sweating process. These points, often situated at the base of the hairs, appear under the magnifying glass as small globules of yellowish color, showing sometimes a radiated structure. Boiling with water or with dilute acetic acid does not remove them, but treatment with dilute hydrochloric acid does so at once. This makes it very probable that the chief mass of these globules consisted of calcium oxalate, a view confirmed by the microscopical observation of gypsum needles forming under the

[1] The writer holds as probable that while $\alpha$-catalase may be generated from a zymogen, $\beta$-catalase is produced from $\alpha$-catalase only, and not from a separate zymogen.

[2] This liquid was prepared from licorice and various condiments, with addition of some rum, according to the prescription given by Marcus L. Floyd in Report No. 62, U. S. Department of Agriculture, p. 19, Cultivation of Cigar Leaf Tobacco in Florida.

influence of concentrated sulphuric acid upon the "grain." Although there is some calcium oxalate present in the living leaf, the oxalic acid of those globules is produced by post-mortem oxidation, since they do not exist in the living leaf, the natural inference being that it is the oxidizing enzyms that produce them by inducing oxidation of various compounds, such as malic or citric acid, tannin, etc. The more oxidizable material, and the more oxidation is going on in the tobacco leaf, the more will the so-called grain develop in the curing and sweating process; hence it will in many cases, by no means in all, confirm the idea of some tobacco manufacturers that a well-developed grain is a good sign for the quality of the tobacco.

The following observations by the writer may be mentioned: A fresh tobacco leaf was divided into two portions. One portion was hung up in a covered beaker containing some water, the other was first heated to 60° C. (140° F.) in a closed vessel before being thus treated. By the sudden killing of the cells by heat the cell sap left them at once and spread uniformly over the surface of the leaf, while in the former case the gradual drying and the later death diminish the migration of soluble matter to the surface. After eighteen days the "grain," in the form of numerous globules of calcium oxalate, was formed in the normally curing leaf, but not a trace of it was seen in the leaf killed immediately after collecting it. This shows that these globular masses were formed in the curing process. In the fresh leaves deposits of calcium oxalate also occur as mentioned, forming crystalline sandy deposits, especially in mesophyll cells. Generally these seem too small to account for the appearance of the "grain" in cured and sweated leaves.

The nature of the "grain" was also investigated by Dr. W. C. Sturgis, who arrived at the same conclusion as the writer and at about the same time. That author had the kindness to communicate the following observations:

> The crystalline deposits are insoluble in water, but are completely and readily soluble in dilute hydrochloric acid. On heating, these deposits swell to three or four times their original volume. Examination under the microscope of these heated masses in water, with the addition of hydrochloric acid, show that they are at once dissolved with copious evolution of gas. These observations, coupled with what we know of the occurrence of calcium oxalate in leaf tissues, lead me to conclude that the grain of certain grades of tobacco is caused by the deposition in limited areas of crystalline aggregations of this salt.

## REMARKS ON THE DEVELOPMENT OF THE BROWN COLOR.

The slow starvation process of the tobacco leaf in the curing barn is connected with the yellowing of the leaves, followed by the characteristic brown. The yellow color is chiefly due to the etiolating of the chlorophyll granules because of the absence of bright daylight, and sets in while the cells are still alive, while the brown color sets in after their death. The changes of the green to yellow and of the yellow to brown start and proceed generally in the same order, commencing at the margin and about midway between the lateral veins. Along

the thicker part of the veins the tissue remains green longest. Gradually a stage is reached in which only the midrib and basal parts of the lateral ribs still have their normal color, being fringed by but narrow strips of yellow mesophyll, the chief mass of the leaf having turned brown.[1] Thus, the layman is inclined to infer that the substance which turns yellow is also the same that turns brown later on. This, however, is not correct. The yellow color is due to a chemical change of the chlorophyll green, while the brown color is due to the oxidation of several different compounds contained in the cell sap. The brown color shows also in the veins of the leaf, but not the yellow, since there is too little chlorophyll in the veins. It sometimes happens, however, that leaves in the barn die quickly by drying up instead of slowly by starvation, thus not allowing sufficient time for development of the yellow color, and in this case the brown color develops directly upon the still green leaf. Such leaves show a distinctly green coloration when held between the eye and the bright daylight, and on treatment with strong alcohol they yield a green solution of chlorophyll, showing that the green is not destroyed, but merely concealed by the brown. The chlorophyll, therefore, is not the source of the brown coloration. Furthermore, when a fresh leaf is dried at a moderate temperature in an air bath it will no longer turn yellow when exposed for a considerable time to a moist atmosphere, showing that the change from green to yellow in the curing barn is still a process of life, although a pathologic one.

As to the brown color, it can easily be shown that it is produced by the action of oxidase and not by the action of peroxidase, since after "killing" the oxidase the brown color fails to develop. Freshly expressed juice of the midrib was heated for four minutes to 75° C. (167° F.) and left with a little chloroform in a flask plugged with cotton. After ten days this liquid was still colorless, although containing peroxidase, while the control liquid became light brown within one day.[2] The juice of the lamina turns dark brown much sooner.

### WHY DOES THE OXIDASE NOT PRODUCE THE BROWN COLOR WHILE THE LEAF IS ALIVE?

The oxidizing enzyms are evidently contained in the plasmatic living part of the cell, and not in the cell sap which fills the vacuoles. On the other hand, the matters easily oxidized by them and representing products of metabolism or by-products of certain synthetical operations are mostly contained in the cell sap. These matters, often of a chromo-

[1] The brown color darkens still more during the sweating process. When the expressed juice of green tobacco leaves, after filtering, is exposed to air it gradually forms an insoluble deposit, the greater part of which consists of a phlobaphen-like, dark-brown substance, and the smaller part of a colorless flocculent compound. The former is easily soluble in dilute ammonia; the latter is not.

[2] It may be mentioned here that, according to A. Mayer, a dark-colored tobacco is obtained by a rich nitrogenous manuring, and that, according to Kosutany, barnyard manure with ammonium salts yields a product of a reddish brown tint, while nitrate manuring yields a more greenish-brown one.

genic character, are, of course, produced in the plasmatic parts, but secreted rapidly into the cell sap. When the cells die the soluble substances locally separated in the cytoplasm and the cell sap intimately mix, since the coagulating protoplasm, becoming easily permeable, can no longer retain any soluble matters—as, for example, oxidase. Thus after death the direct action of the oxidase on the oxidizable matter of the cell sap sets in with a production of colored bodies, as is the case in the tobacco leaves. This action can also be noticed very well in the juice pressed out from the fresh leaves, since this juice, containing cell sap as well as soluble matters previously contained in the protoplasm, turns brown rapidly on coming into contact with air. The darkening of the juices of potatoes, beets, and other plants depends upon the same principle.

### CHROMOGENS OF TOBACCO.

The nature of the chromogenic compounds has not yet been fully revealed. It was pointed out in Report No. 59, p. 12, that several different compounds have to be assumed as contributing to the color in the tobacco leaf, and that tannin as well as nicotine contribute only a part of it. It is true that the darker tobaccos are generally considered as being the stronger—that is, contain the most nicotine—but, on the other hand, it has to be kept in mind that the veins, which contain less nicotine than the lamina, are generally much darker colored, a fact hardly to be explained merely by the thicker layer of cells. The fact, however, that the juice of the lamina turns dark more quickly and intensely than the juice of the rib makes it probable that the chromogen of the ribs is not easily soluble and differs from that of the lamina. In the lamina it is the mesophyll and not the epidermis that contains the chief quantity of the chromogen.

The main chromogens of the leaves are insoluble in alcohol, as is the brown product itself. A piece of young, green tobacco leaf was left in alcohol for one day, the chlorophyll being extracted and the leaf becoming almost colorless. Upon moistening with water it turned brown within two days, the color being darkest in the ribs and veins. The main chromogen, therefore, had not been removed by the alcohol treatment.

There is but very little chromogen in the pith, since it becomes only slightly brown after several days' exposure to the air; equally little is contained in the vascular bundles of the stalks, except in the youngest part. The study of the nature of the chromogens encounters considerable difficulties.[1]

[1] After this was written, an article of Behrens appeared in the Landw. Vers. Stat., vol. 52, in which he discusses the production of the color. He thinks that the brown substance is formed from a chromogen which is split off from a glucosid, and that this glucosid is formed during the first or starvation period of the leaves in the barn. This opinion can hardly be accepted when we observe the rapidity with which the juice of the fresh leaves turns brown upon exposure to the air, showing that the chromogen, or rather the "soluble" chromogen, is already present in the normal leaf.

## SUNBURNED TOBACCO LEAVES.

When the tobacco plants are harvested it often occurs that the cut plants are left for several hours in the field, exposed to a scorching sun, and many of the leaves are killed either in part or in isolated spots. These prematurely killed portions remain green and never change color in the curing barn. There are, indeed, not infrequently found among the cured leaves of commerce some with green spots on them, due to this circumstance. The microscope reveals the fact that the fine veins of such spots are only of a faint brown color, compared with the well-cured portions.

It appears to be of some interest to decide whether it is only the effect of the intense light which causes such a change in the properties of the leaf, or whether a partial drying up in the sun forms one of the conditions. Possibly the light may kill the enzyms as soon as the cells themselves are killed by the heat. The gathered leaves warm up with the sun's rays considerably more than the leaves of plants standing in the field, where the transpiration current provides moisture which lowers the temperature by continuous evaporation.

A piece of ripe leaf was heated in a closed test tube in a water bath for five minutes to from 60 to 61° C., which caused the loss of the natural stiffness (turgor), the change being caused by the loss of the osmotic properties of the plasma sack when the leaf dies. Another piece of the same leaf was heated to 60° C. for five minutes, and then for five minutes longer to a temperature of from 70 to 71° C. Both of these pieces were hung up in a covered beaker containing some water, and compared with another piece of the same leaf not so treated. After eighteen days the pieces were moistened and spread on a glass plate, when it was easily recognized that the color of the piece heated to a temperature of from 60 to 61° C. was almost the same as that of the control piece, while the color of that heated finally to a temperature of from 70 to 71° C. had a far different look, only the larger veins having become brown,[1] while the lamina was of a weak yellowish green. This shows that the production of color is due to the action of the oxidase (not yet killed at 60° C.), and not to the peroxidase (not yet killed at 70° C.), since a special test proved that the piece heated for five minutes to a temperature of from 70 to 71° C. contained considerable peroxidase, but no longer any oxidase. Still the analogy to the sunburned leaves was not fully established by this test, since the sunburned leaves retain their full natural green, while with the samples mentioned the original green was somewhat changed. Tests in which the pieces of the leaf were not, however, treated in closed test tubes, but were left to dry openly in an air-bath at 58° C., gave a different result. In these the green was preserved almost in its natural condition, and

[1] This browning was probably developed between 40 and 66°, after the death of the cell and before the death point of the oxidase was reached.

the subsequent exposure to the moist air led only to a coloration of the veins. The lamina remained green. The simultaneous effect of heat and of drying up must unite, therefore, to produce the phenomena observed in "sunburned" leaves.

### "WHITE VEINS."

The phenomenon of "white veins" is observed in the curing barn after a long spell of dry and warm weather. The veins then lose the capacity of turning brown on the surface, and preserve a whitish or rather colorless appearance after the curing process is over. On holding such a leaf between the eye and the light, a sufficiently dark-brown coloration of these veins is plainly seen, hence it is only the surface which is devoid of coloring matter. There is hardly any other explanation than that by a too rapid drying the epidermis cells of the veins died too quickly and this premature death caused the entrance of air into and perhaps also below them,[1] leading to the optical illusion that coloring matter is absent in the veins, although the interior cells (those of the vascular bundle) contain it.[2] The microscope reveals colorless and air-containing tissue around the brown sieve-tissue masses in the "white veins," while in the normally colored veins the tissue surrounding the sieve tissue is more or less yellowish brown. The presence of "white veins" decreases the value of the wrapper leaf, while it has no influence upon the value of the fillers. On the contrary, such fillers may often be very valuable. To prevent the "white veins" there seems no other way possible than to keep the barn closed in prolonged hot, dry weather and to occasionally sprinkle water through the barn.

### "SALTPETER" ON TOBACCO.

A phenomenon resembling to some extent that of "white veins," but in reality very different from it, is the efflorescence of a white saline mass upon the midrib and lateral ribs of the curing tobacco leaf. The tobacco planters and manufacturers call it "saltpeter," but sometimes there are only traces of saltpeter (nitrates) found in these efflorescences. They contain principally a mixture of potassium, sodium, calcium, and nicotine salts. The writer has not chanced to observe an efflorescence consisting only of saltpeter, although the possibility of such an occurrence can not be denied. The phenomenon is probably caused by a long spell of dry weather in the first stages of the curing.

Finally, it may be mentioned that sometimes a white mycelium of some fungus makes its appearance on the veins of the curing leaf,

[1] Such a phenomenon is also frequently noticed in August on the leaves of the peach tree, as Dr. Galloway has kindly pointed out to the writer.

[2] Mr. Floyd reported to the writer that occasionally white veins are also noticeable in plants while growing in the fields, and that in such cases the leaves are usually of a very dark green.

since the veins retain more moisture than the lamina and thus favor fungous growth more than the latter. This phenomenon is, however, very easily distinguished from that of the genuine "white veins."

## METHODS OF SWEATING.

There are three methods of sweating practiced in the United States, viz:

(1) The natural sweat in cases.
(2) The forced sweat in cases.
(3) The sweating in bulk.

The natural sweat is a slow process going on in cases. The low temperature in winter and spring in conjunction with the limited access of air is, however, an unfavorable condition. Besides, the absence of an energetic sweating process favors the growth of fungi upon the tobacco leaves when the tobacco has been packed too moist. The higher temperature used in the other two methods hastens the process of sweating and the development of aroma, and thus the tobacco can be put on the market a considerable time in advance of what could ordinarily have been done. The advantage of an early market is much desired by all packers.

The "forced sweat in cases" requires about the same length of time as the "sweating in bulk." A natural sweat for from six to ten months, followed by a sweating in bulk for from two to four weeks, is applied in Lancaster, Pa., for filler tobacco. Only when fear of must exists is new tobacco there at present subjected directly to the "forced sweat in cases," and this process is sometimes followed by a short "sweating in bulk" when the color for the fillers has not become dark enough.[1]

An important difference between the "sweating in bulk" and the "sweating in cases" is the greater access of air in the former method. The amount of oxygen for the "sweating in cases" is restricted to that contained in the air of the cases[2] and in the air which enters through the sides and at the corners. By this lessening of the access of air the processes of oxidation are retarded and a considerable rise of temperature by the sweating itself is prevented. Hence, this method is carried on in rooms at from 37.7° to 43.3° C. (100–110° F.) without fear of undue spontaneous further rise in temperature in the tobacco

[1] Dark fillers and light wrappers are at present in demand. A thorough sweat, although leading to a fine aroma, will also produce a dark color, hence the sweat has to be limited when wrappers of a light color are to be produced. This is one of the reasons that the wrappers are moistened with less water than the fillers before sweating. The tip of the leaf is better adapted for wrappers than the base or "heel," as the tobacco manufacturer calls it, on account of its greater flexibility—produced by differences in the vascular bundles near the tip which consist mainly of spiral vessels, while near the base there are also pitted vessels.

[2] This amount is small, as the tobacco leaves are packed in cases with the aid of a press. No pressure is applied for the fermentation in bulk, in order not to diminish the necessarily limited access of oxygen.

itself. The cases are piled up in these rooms heated often merely by an iron stove, which holds a vessel of water to produce a moist temperature so as to prevent the tobacco from drying out too much.

With the "sweating in bulk" the condition differs.[1] The rooms generally have a temperature averaging from 21–28° C. (70–85° F.), and the only covering for the tobacco consists of blankets, which admit air freely between the sweating "hands" of tobacco. The oxidation processes can therefore be carried on with much more energy, leading to a considerable rise in temperature above that of the room, a rise amounting daily to from 5 to 8° C. (9 to 14° F.). A great advantage of the fermentation in bulk is that these bulks are repeatedly turned over and rebuilt, which enables a minute examination. A careful workman is thus able to observe whether the process is going on normally and can frequently remedy troubles. The forced sweat in cases, however, does not have this advantage. As to the ammonia produced by the sweating, there can be no doubt that it is a normal product of the destruction of the nitrogenous compounds by the oxidizing enzyms, and not a product of putrefaction, as held by some authors. The writer showed in Report No. 59 that bacteria of putrefaction can not thrive upon tobacco leaves in the sweating condition. Every normally sweated tobacco contains some ammonium salts.[2] It depends upon the amount of ammonia thus formed whether a tobacco of commerce shows a faintly acid, a neutral, or a faintly alkaline reaction.

As to the question which especial compounds are attacked in the sweating process by the oxidizing enzyms in the leaves, it is probable that all soluble organic compounds present in the leaf are attacked, but with a different degree of intensity. Although certain compounds, such as nicotine, may be attacked with difficulty, a noticeable amount may nevertheless become oxidized in the course of time, since the sweat in the bulk or the forced sweat in cases lasts about six weeks. The oxidation need not lead directly to the production of carbonic acid with every compound, as there may be formed intermediate oxidation products, which undergo further oxidation but slowly. By allowing the temperature to rise to about 65° C., which is 5 degrees higher than the generally adopted maximum, the oxidation may even extend so far that the aroma first produced is again destroyed and that the extractive matters are diminished until a very large percentage of the tobacco consists of mere cellulose. Tobacco manufacturers call such an inferior product "papery." Nevertheless the temperature of the fermenting wrappers in Sumatra is sometimes

[1] Report No. 60, U. S. Department of Agriculture, Temperature Changes in the Fermenting Piles of Cigar Leaf Tobacco, by Milton Whitney and Thomas H. Means. This report contains a full description of the "sweating in bulk" as practiced in Florida.

[2] Thoms obtained 38 grains of ammonium sulphate from 15 kilograms sweated tobacco on distillation with steam; but only a part of the ammonia is obtained in this way. Various analyses give from 0.05 to 0.5 per cent ammonia in tobacco.

allowed to reach 65° C. (109° F.), as Van Bemmelen reports.[1] When this temperature is kept up for some time or is allowed to rise some degrees higher, the tobacco loses its power of heating up again when the heap is repacked. The oxidase and catalase are now killed. Such tobacco is called "cooked." It is knotty and curled and the fiber has lost much of its elasticity.[2]

### NOTES ON THE BACTERIAL HYPOTHESIS OF SWEATING.

Although it was shown in Report No. 59 that Suchsland's bacterial hypothesis of the sweating of the tobacco is unfounded and that the true cause of the oxidation in the sweating process must be attributed to the presence of oxidizing enzyms in the tobacco leaf itself, nevertheless some persons still adhere to the bacterial hypothesis. But it is a simple matter for anyone to convince himself by direct microscopical examination of scrapings from moistened sweating wrapper leaves that the numerous bacteria which would be expected, by the hypothesis, are not there. Even if we assume that the supposed tobacco bacteria are characterized by extraordinary capacities of oxidation and fermentation, and that therefore a restricted number might account for a great deal of work, several millions at least should exist for every square inch. Further, it is evident that the conditions on the tobacco leaves are most unfavorable for bacterial growth. It was pointed out by the writer that the water content of a fermenting wrapper leaf is utterly insufficient to bring the nutritive compounds from the interior of the cells to the surface, the moisture being barely sufficient for the proper imbibition of membranes and cell contents. The easily soluble matters, such as oxidizing enzyms, will no doubt dissolve, but this solution will be retained in the chief mass of the cell contents.

Let us assume that all the water of a sweating leaf would be available for the cell contents—none being retained by imbibition of the cell membranes—and, further, that one-half of the cell contents is easily soluble in water, although in reality two-thirds are easily soluble in their own weight in water. A fermenting wrapper leaf with a water content of 20 per cent[3] would then contain a solution of organic matter of a strength of 50 per cent, since ripe wrapper leaves of good quality and capable of fermentation contain in the dry substance an average of 40 per cent of matter soluble in water.[4] In such a solution of 50 per cent of organic substances bacteria can not multiply. Even mold

[1] Landw. Vers. Stat. vol. 37, p. 383.

[2] This is the experience of tobacco manufacturers of Florida, and has been mentioned to the writer by Mr. M. L. Floyd.

[3] The tenacity and cohesion of wrapper leaves are generally seriously injured as soon as the water content is increased above 27 per cent while the sweating is going on.

[4] Of course the percentage of soluble matters varies considerably in different grades of tobacco.

fungi find it rather difficult to live under those conditions.[1] In reality the conditions are still much less favorable for bacteria than we have assumed in this calculation. The high temperature is also an obstacle to most bacteria. Fermenting wrapper leaves sometimes reach a temperature of 60° C. (140° F.), and still ferment again when the heap is repacked. It would be a very easy matter to isolate the active bacteria, if they should belong to the few thermophylic kinds that can be active in such a high temperature. But nine years have passed since the promulgation of the bacterial theory of tobacco fermentation, and thus far there is nowhere to be found a scientific description of the supposed tobacco bacterium.

The following experiment shows that bacteria from the very surface of the tobacco leaves can not thrive in a concentrated tobacco extract. Such an extract containing 30.2 per cent of solid matter was sterilized and a small piece (about 1 cm. square) of a freshly cured tobacco leaf[2] introduced, after which the flask was plugged with cotton. After 10 days neither a scum nor a turbidity indicating the presence of bacteria could be noticed, but some clot-like masses were observed. These masses proved to consist of a mycelium of a fungus, while even with the highest magnifying power no microbes could be observed. However, a dilute solution, prepared by diluting the former with ten times its volume of water, formed a bacterial scum within two days upon exposure to the air.

In a second trial, with a concentrated solution of 25 per cent of tobacco extract (contained in a test tube) exposed to the air for ten days to admit various kinds of microbes, there was neither a scum nor a bacterial turbidity produced. On microscopical examination, however, some few bacteria could be noticed. Now, if solutions of such concentrations are so very unfavorable for bacterial growth, how much more must this be the case for the much higher concentration to be found in the cells of the fermenting wrapper leaves?

Further experiments proved that even at a water content of 35 and 40 per cent present in fermenting fillers[3] bacteria can not flourish upon the leaf surface at the temperature of the fermenting piles. In freshly cured heavy tobacco the water was determined and enough water added so that in two samples the percentage reached 35 and 40 per cent, respectively. These leaves were rolled up and placed in flasks, which were sealed with paraffin and kept for five days at a temperature of from 53° to 55° C., there being an abundance of air in the flasks. For

[1] According to Splendore (Revista Tecnica, Roma, 1899), Oospora Nicotianæ can not develop upon tobacco that has less than 26 per cent of water, and, according to Behrens (Landw. Vers. Stat., Aug., 1899), Botrytis requires at least 30 per cent of water in cured tobacco to be able to grow on it.

[2] This tobacco contained catalase, oxidase, and peroxidase and was subjected to "sweating" or "fermentation in bulk." It sweated normally.

[3] Hands of filler tobacco are dipped with their base deeper into the water than hands of wrapper tobacco, thus securing a higher water content.

a short time the temperature reached 59°, but since even 60° is frequently observed in the fermenting tobacco piles this temperature should not be expected to kill the supposed tobacco bacteria. The microscopical examination of the leaves after five days proved the absence of a bacterial coating. Only here and there a microbe was found, but upon staining and counting in everything which had any resemblance to a spore or bacillus there were not more than 600 microbes to the square inch. The examination was made not only of scrapings of the moistened surface, but of the triturated parts of the leaf itself.

Recently a treatise by H. Vernhout has appeared in which a microbe closely related to Bacillus subtilis is described from fermenting tobacco leaves in Java.[1] The author ascribes to this the phenomena of tobacco fermentation. The proof, however, that this microbe can produce fermentation and can multiply on tobacco leaves with only 25 per cent water has not been adduced. His further remark that a sample of cured tobacco did not contain any oxidase or peroxidase does not require any further comment, since these enzyms may disappear as above mentioned under unfavorable conditions, while catalase, the third oxidizing enzym, still may persist.

## SWEATING MUSTY TOBACCO.

The complaints about "musty tobacco," "white mold," and "black rot" in tobacco packed in cases are quite frequent. Moist weather toward the end of the curing, and especially while stripping and packing are going on, favors these injuries. Apparently quite healthy tobacco will often, after having passed through the natural or cold sweat, have a moldy odor[2] or a cover of a white film of fungus mycelium, or even patches where the leaves are transformed into a powder by the so-called black rot.[3] Dark heavy tobacco is said to be most damaged by "white mold." Because of this damage the value of the tobacco is decreased to about one-sixth of the original. A tobacco manufacturer assured the writer that out of 1,600 cases of tobacco of a particular crop he found 1,300 cases more or less damaged in this way, and he estimated the damage annually caused in this country at about $1,000,000. Repacking after removing the worst portions affords but a poor help and but for a short time. In the case of black rot further serious damage can be prevented more easily by repacking, since this fungus does not continue to spread after cold weather sets in in autumn. The chief remedy

[1] Onderzoek over Bakterien bij de Fermentatie der Tabak, Batavia, 1899.

[2] The moldy odor is caused by the growth of the common mold fungus, *Penicillium glaucum*.

[3] In a case of black rot examined by Mr. E. A. Bessey, in which the cohesion of the parts of the leaf was destroyed and patches of it transformed into a pulverulent mass, the fungus *Sterigmatocystis nigra* (*Aspergillus niger*) was found.

applied at present is a "forced sweat," in which the musty odor disappears and the mycelia of the fungi are killed; but when this process is not thoroughly carried on the spores may be uninjured, and thus it happens that the musty odor may come back again when these spores develop.

This forced sweat is carried on in the presence of much water—45 or 50 per cent—and is therefore suitable only for fillers, since under such conditions the wrapper leaf would deteriorate considerably. The writer has observed that with a room temperature of 26.6° C. (80° F.) and a water content in the tobacco of 47.6 per cent the temperature of a large box filled with such moistened musty tobacco was markedly increased within four hours, and in two days reached a temperature of 40.5° C. (105° F.). From three to four days are allowed for this sweat in summer, and from one to two weeks in winter.[1] Tobacco that has passed through a "forced sweat" will not again heat up sufficiently, while after a cold or natural sweat it will heat up readily.

Some suggestions might be made as to how to prevent, as far as possible, the deterioration of cured tobacco by fungi. Whenever the stripping cellars are underground or immediately under the curing barn, the moisture of the air in the cellar often increases to such an extent that the stripped tobacco absorbs too much moisture before it is packed. When the water content of tobacco rises above 30 per cent there is great danger of the development of fungus spores which may be present on the tobacco leaves. Besides, in such damp localities various fungi develop on the floor and walls where organic impurities have gained lodgment, and hence the opportunities for the infection of the tobacco in the stripping process are much enhanced. Some farmers have recognized this dangerous source of infection and fumigate the stripping cellars with burning sulphur before commencing the work. The mycelia of fungi can easily be destroyed by this process, but the more resistant spores may escape destruction. Another means of cleaning the cellars is to whitewash them several times with freshly slaked lime and dry them out well with artificial heat before the stripping commences. It would be still better to have the stripping localities above ground and have them kept warm while the stripping is going on.

An essential step of progress would be made by giving up altogether the natural or cold sweat and by replacing it with the "sweating in bulk," to be carried out soon after the curing process is finished. The fungus spores, the germination of which is hastened by heat, are gradually killed in that state when the temperature rises above 50° C., and thus the fungus development injurious to the tobacco is easily avoided.

A few words may be said in this connection about measures for the prevention of stem rot. "Stem rot," a disease sometimes developing and spreading in the curing barn, has been investigated by Dr. W. C.

[1] Sufficiently sweated tobacco is generally not packed again, but serves directly for the manufacture of cigars.

Sturgis, who named the fungus *Botrytis longibranchiata.*[1] He recommends that all the diseased stems and leaves be collected and burned at once, before the fungus is further developed and before its spores can be scattered about by any current of air. He further suggests sprinkling the floor of the barn with a mixture of equal parts of air-slaked lime and sulphur, and the fumigation of the tightly closed barn with burning sulphur a fortnight before the tobacco is harvested, and again after the removal of the cured tobacco from the barn. It may be added here that washing the floor with thick milk of lime which has been recently slaked in the usual way has also been found beneficial.

## AROMA OF THE TOBACCO.

The odor developed in smoking a cigar may be partly due to the mere volatilization of products of the sweat and partly to the destruction of certain compounds. The heat of the glowing surface reaching the neighboring sections which are not in full contact with air causes there volatilization and various decompositions by dry distillation. Products of pleasant and of unpleasant odor are components of the smoke, and it is the chief aim of the progressive dealers in the tobacco trade to reduce the amount of the latter components to a minimum. In the smoke of tobacco have been found besides carbonic acid and water, nicotine, ammonia, carbonic oxid, occasionally nicotianine and traces of hydrogen cyanide, and hydrogen sulphide. Recently pyridine, trimethylamine, and butyric acid have been found in it by Thoms.[2] The pyridine is produced by the decomposition of nicotine, while the hydrogen cyanide, hydrogen sulphide, and butyric acid are probably derived from protein compounds.

The soil, climate, and weather on the one hand and careful treatment in the curing and sweating of the tobacco on the other have great influence in the production of a cigar leaf having the proper aroma in smoking. This flavor must be distinguished from the odor which the sweated tobacco leaves show directly without being heated or smoked. The writer proposes to designate the former alone as aroma, while the latter will be called simply odor. The use of this distinction is made in the following lines.

The odor of the sweated tobacco leaves doubtless stands in a certain relation to the aroma generated in smoking, generally a pleasant odor justifying the inference of a fine aroma; but this is by no means always so, and cases occur where a sweated tobacco of pleasant odor produces a disagreeable odor on being smoked. The aromatic substances may here escape perception because of the presence of other and undesirable compounds. The substances which impart the odor are easily soluble in water, since tobacco extracted with water and dried again has no longer

[1] Conn. Agr. Expt. Station, Annual Report, 1891, p. 185.
[2] Chem. Zeitg., 1899, No. 80.

its characteristic odor. "Nicotine free" cigars made of such tobacco are also devoid of any trace of aroma. Treatment with much alcohol also removes the odor more or less, and this alcoholic extract on evaporation at the ordinary temperature leaves a residue recalling the odor of the tobacco. This residue upon treatment with ether can be separated into a soluble and an insoluble part, but neither of these has any odor, showing that the substances which caused the odor are easily volatilized or chemically changed. Indeed, they are easily changeable, as can be observed when sweated tobacco is distilled with water. Five hundred and fifty grams of Florida tobacco of a superior odor were mixed with eight times its weight of water and nearly 300 c. c. were distilled off. On the surface of the slightly turbid distillate, which had a weak but rather disagreeable odor, resembling somewhat that of rancid oils, minute oil drops were seen. Not only was the distillate devoid of any specific odor, but also the contents left in the flask had lost the original odor. The odor is also easily removed by dry heat. Two hours exposure to air at a temperature of 100° C. (212° F.) suffices to deprive tobacco of most agreeable odor of this desirable quality.

Tobacco leaves, even from the best tobacco regions, are by no means distinguished by peculiar flavor in their fresh or cured state.[1] The curing exerts a beneficial effect upon the quality of the aroma only in so far as a part of the protein is destroyed by it. Cured tobacco, even from the best sources, has a mere straw odor. The fine odor and genuine aroma are generated by the sweating process. The better regulated the sweating process, the finer the aroma, other things being equal. Whenever the sweat is not proceeding well—ascribed sometimes to a high fat content, or perhaps caused by imperfect curing, or by injuries to the oxidizing enzyms in the curing barn—the product will have a poor aroma. These circumstances make it clear that the original resin in the leaves can not be the cause of the aroma, as some authors have surmised. Indeed, the resinous matter from fresh or cured leaves does not show any particular flavor when heated; neither has the ethereal oil contained in the hairs of the fresh leaves a beneficial effect on the quality of the tobacco.

It is well known that it is especially the so-called gummy leaves that sweat best and give the finest aroma. Such leaves are found among the upper and not among the lower or sand leaves, and are very rich in extractive matters. When such leaves are shrinking in the process of drying in the curing process, these soluble matters may sometimes be forced to the surface, to some extent, in the form of a concentrated solu-

[1] While the juice of fresh tobacco leaves assumes, after a short time, the odor of cucumbers, fresh leaves dried at 50° C., and afterwards moderately warmed with water, gradually develop the agreeable odor of dried malt; an interesting fact, since the germinating barley on the malting floor also at first develops the odor of cucumbers.

tion, hence such leaves feel sticky or gummy to the touch. By a thorough sweat this "gum is taken out," as the manufacturer says; in other words these extractive matters are more or less oxidized.[1] It is therefore of interest to determine the amount of soluble matter left after sweating. This amount varies considerably, from 30 to 54 per cent. The insoluble matter consists mainly of cellulose, lignin, protein, coloring matter, fat, resin, and ash. With some samples the following results were obtained:

| | 1. | 2. | 3. | 4. |
|---|---|---|---|---|
| Soluble | 37.1 | 33.8 | 37.5 | 44.3 |
| Insoluble | 62.9 | 66.2 | 62.5 | 55.7 |

Sample No. 2 showed saline efflorescences (so-called "saltpeter") on the veins. Sample No. 4 consisted of co-called "gummy leaves." The ash varied from 19.4 to 22.1 per cent in those samples.

It was formerly believed that the aroma was chiefly due to the so-called tobacco camphor or nicotianine—a crystalline volatile product which was obtained by distillation of sweated tobacco with water. Hermbstadt tried, as early as 1821, to isolate this aromatic principle. On distilling various samples with six times the weight of water he obtained a distillate yielding a precipitate with acetate of lead, from which a crystallized compound of a strong tobacco flavor was obtained, which he called nicotianine. Later on this product was studied by Posselt and Reimann, and also by Barral. Two formulas have been calculated from Barral's results, namely, $C_{23}H_{32}N_2O_3$ and $C_{36}H_{48}N_3O_5$. Barral states that it yields nicotine on distillation with potassa. This product may possibly be formed from nicotine in the process of sweating, but it is by no means contained in every tobacco. A number of chemists have failed to observe it and the writer has tried in vain to obtain it from Florida tobacco. The aqueous distillate from the Florida tobacco contained, besides small oil drops, some ammonium carbonate, and the precipitate obtained with basic acetate of lead was nothing but lead carbonate.[2] Probably the nicotianine is only an occasional product in very heavy tobacco. Odor as well as aroma is evidently caused not by a single compound, but by a mixture of com-

[1] The word "gum" is applied in other countries in the same sense as the word "life" is with tobacco in America, signifying a certain elasticity of the tobacco leaves. The word "gum" in this connection is derived from the erroneous idea that the elasticity is caused by a content of "gummi elasticum" or caoutchouc. Behrens has recently shown that the "life" of fermented tobacco leaves is due to a greater amount of hygroscopic moisture, caused by a higher percentage of malates of potassa and soda.

[2] The results obtained by the firm of Schimmel & Co., in Leipzig (recently published in Chemiker-Zeitung, 1899, No. 80), are in full accord with the writer's observations. No nicotianine, but considerable ammonia was present in the aqueous distillate of the sweated tobacco tested.

pounds, nicotine contributing in a certain measure to the formation of these.[1]

It was observed by Jenkins, Behrens, Kissling, and others that a certain amount of nicotine (one-fourth to one-third) is destroyed by the process of sweating; hence it is natural to connect the formation of aromatic products with the disappearance of a certain portion of the nicotine. Cured tobacco rich in nicotine may, by a thorough sweat, become poor in nicotine and rich in aroma, while after an insufficient sweat it will be rich in nicotine but poor in aroma.

It is a well-known fact that a high content of nicotine in a cigar is often associated with a poor aroma. Strong cigars are not always the best. But all attempts to produce by partial oxidation of nicotine substances of an aroma similar to that of good cigars have thus far failed. By moderate oxidation, as brought on by silver oxide or hydrogen peroxide, nicotyrine and oxynicotine result, while by a more powerful oxidation nicotic acid is formed—products which have no relation to the odor and aroma of sweated tobacco. The writer has also applied platinum-black as an oxidizing agent. It was left to act for several weeks on a 4-per-cent aqueous solution of nicotine at the ordinary temperature as well as at about 50° C., but the desired effect was not observed, although the nicotine became much altered. Evidently the oxidation, caused by the oxidizing enzyms in the sweating heaps, takes a different direction.

Recent investigations of Thoms[2] have shown that the flavor of the tobacco smoke is chiefly due to an ethereal oil which is produced by dry distillation in the process of smoking from a product of the sweat. Twenty kilos of tobacco, smoked by an aspirator, yielded 75 grams of this oil, which was of a stupefying odor and produced headache and trembling of the limbs when inhaled in a concentrated state. It contained, among other things, 9 grams of a phenol of creosote-like odor.

The best method of avoiding the poisonous action of the tobacco smoke while enjoying its beneficial stimulating effects is found with the Turks, Arabs, and Persians. The use of a wash bottle (nafas) before the smoke reaches the mouth removes a great deal of the poisonous products. Géorgiades found that each 18 grams of tobacco (a pipe full) showed 0.947 gram nicotine, the nafas through which this quantity of tobacco was smoked showed 0.595 gram nicotine, while the washed smoke from same amount contained but 0.0225 gram.

### INJURY TO THE AROMA.

The aroma may be injured by various causes, as, for example, by a high content of fat or of protein in the tobacco. Certain tobaccos which

[1] Opinions as to the formation of the aroma are much divided. Van Bemmelen (Landw. Vers. Stat. 37, 388) holds that the organic acids of the leaves have a certain influence.

[2] Chem.-Zeitg., 1899., No. 80.

have a fine odor at the ordinary temperature have but a poor aroma when smoked, since the aromatic substances may be disguised by the products of dry distillation of fat and protein when the cigar is smoked. A high fat content is indeed very injurious. Other compounds also, interfering seriously with the aroma, appear sometimes to be produced under certain climatic conditions. For example, the tobacco produced in Connecticut in the unusually wet season of 1897 was so inferior that the sales did not pay the outlay for fertilizers.[1] The buyers claimed that the cured tobacco had a "stink" about it and that it also showed a similar odor after sweating. Such injurious products seem not infrequently to be present. It is on this account that tobacco is subjected in certain factories to a strong current of air for twenty-four hours at the ordinary temperature, in order to take out the "rank" odor before it goes to the bench for cigar making. Indeed the air which has passed through such tobacco contains a very sharp substance which brings tears to the eyes.

The influence of climate upon the formation of certain products in the tobacco plant may also be inferred from an observation made by Schimmel. While 43 kilograms of tobacco from South America yielded on distillation with water mere traces of a volatile oil, 15 kilograms of German tobacco yielded 6 grams of a thick and dark-colored oil having an odor similar to that of camomile. This oil contained, according to Thoms, no terpens, but it contained among other things a small amount of a phenol. A further injury to the aroma is to be expected from the treatment of the tobacco in the field with paris green and other arsenious preparations to destroy caterpillars. Many tobacco growers avoid the use of such preparations altogether and do not begrudge the extra expense for the labor required in picking off the caterpillars by hand. Others apply Paris green only in the young stages of the plant—1 part well mixed with 100 parts of flour—but in certain districts, where caterpillars occasionally become very numerous, Paris green is applied on the ripening leaves in proportions of about one-fourth of a pound to 40 gallons of water. In one pound of sweated tobacco from such fields M. Peter found from a trace to 1.7 grains arsenious acid.[2] Such tobacco when smoked may be expected to have a disagreeable odor, since even the smallest quantity of arsenious acid produces, in contact with a glowing substance, a disagreeable odor resembling that of garlic. But more serious than the injury to the aroma is the injury to health when such poisoned tobacco is habitually smoked. An injury to the odor of tobacco may also be caused by the development of certain fungi on cigars kept in a too moist atmosphere. Even a putrid odor may thus be produced, as Splendore has observed in one case.[3]

[1] On the other hand too dry seasons are just as injurious, since the tobacco produced may refuse to sweat.

[2] This would correspond to 0.025 per cent arsenious acid or about 0.05 per cent paris green.

[3] Il tobacco, p. 11, 1899.

Numerous experiments have been made to improve the aroma of poor tobacco. Oxidizing media have been applied to destroy supposed injurious by-products. The writer tested the action of a 1 per cent solution of potassium permanganate for five minutes, but the results were not encouraging, on account of the injury to certain other properties.

Other methods consist in the application of substances of powerful aroma. For example, we find among the ingredients for the preparation of petuning liquids anise seed, cloves, cinnamon, coffee, and tincture of valerian.[1] In Cuba tonka beans and vanilla beans are also used to improve the aroma, but with very rank tobaccos even such ingredients prove insufficient. The important question of how to improve poor products deserves careful attention and further detailed study.

### NITRITE CONTAINED IN SWEATED TOBACCO.

Although the tobacco of commerce has been the object of frequent and numerous analyses, one compound occasionally occurring in it has thus far been entirely overlooked. It is the nitrous acid present in the form of nitrites. While nitrates frequently occur in various living plants and also in fresh tobacco leaves, nitrites do not. Indeed, these salts would act very poisonously on the living cells if they accumulated to even a small degree. The writer has observed that the poisonous character of free nitrous acid is so great that it kills algæ after one day, even at a dilution of 1 part to 100,000 parts, although its acid character is so weak that it is easily liberated from the nitrites by dilute organic acids, such, for example, as are contained in the cell sap of most plants; hence the salts of nitrous acid are also very strong poisons wherever an acid-cell sap in the plants can liberate nitrous acid from them.

When tobacco leaves rich in nitrates, however, are subjected to the sweating process after being cured a portion of the nitrates is reduced, whereby, as an intermediate step, nitrites are formed, ammonia representing the final product. Some sweated tobaccos are so rich in nitrite that a concentrated extract, even when prepared in the cold, gives a decided odor of nitrous acid upon the addition of sulphuric acid, and even the smallest quantity of the extract produces at once separation of iodine from potassium iodide on addition of a little sulphuric acid. When upon dilution the brown coloration of the tobacco extract is sufficiently diminished, the well-known test of Gries for nitrites is also easily obtained. The tobacco extract containing nitrites gives a blue reaction with tincture of guaiac, but this reaction of nitrous acid is also obtained after boiling the extract for a minute, while the similar blue reaction caused by oxidase is made impossible after heating the extract a short time to 67° C. (153° F.), or, if the extract is weakly alkaline,

[1] Report No. 62 (p. 17), U. S. Department of Agriculture. Marcus L. Floyd.

to 75° C. (167° F.). By this control test erroneous conclusions can be avoided.

An accumulation of nitrites in the sweating tobacco might in the course of some weeks attack the oxidizing enzyms at the temperature of the fermenting heaps, thus terminating this process sooner than desirable. Hence nitrates should not be applied in too large quantities in the manuring of tobacco fields, since they may give rise to the formation of nitrites in the sweating process. Bacterial action need not be assumed in this process.

### AMOUNT OF HEAT PRODUCED BY SWEATING IN BULK.

Since the loss of organic substance from the cured leaves in the sweating in bulk amounts to about 5 per cent dry matter, and the cured leaves consist of nearly 40 per cent of carbon and 6 per cent of hydrogen, an approximate calculation can be made as to the amount of heat generated by the oxidization going on in the heap. For an accurate calculation it would be necessary to know the exact amount of carbonic acid and water formed by the oxidation, and further, how much of the carbonic acid was generated from previously present carboxyl groups, and how much water was generated from previously present hydroxyl groups; moreover, it should be known how much total ammonia is produced in the sweat. But, on the assumption that only one-half of the carbonic acid and one-half of the water produced are due to perfect combustion, and that the carbon and the hydrogen in these products show the same proportion as in the cured tobacco, we will obtain numbers which are certainly rather an underestimation than otherwise. The fermenting piles are made up of from 2,000 to 7,000 kilograms of tobacco. Let us assume a pile with 2,000 kilograms of dry matter. The 5 per cent loss after the sweat would then amount to 100 kilograms. According to our assumption this would involve a complete combustion of 20 kilograms of carbon and 3 kilograms of hydrogen. Since one gram of carbon produces 7,678 units of heat and one gram of hydrogen 33,808 units of heat, it follows that 20 kilograms of carbon would yield 153,560 major calories and 3 kilograms of hydrogen 101,400 major calories. This heat would suffice to heat up 254,960 liters of water for 1° C.

### CONCLUSION.

Various problems relating to the manufacture of tobacco have been touched upon in this report, some of them within easy reach of solution, others of a very difficult nature. The prevention of fungous attacks in the barn or in the cases, the regulation of the temperature and humidity in the curing process, and the proper control of the sweat are points that can easily be settled. In many cases the replacement of the stalk-curing by the single-leaf curing process may prove a financial success. But there are other problems of a more

delicate and difficult nature, as the prevention of the mosaic or calico disease and the proper composition of the tobacco leaf while ripening. Upon this composition depends the development of a desirable aroma in the sweating process. Climate and weather are here such potent factors that human art can accomplish directly but little. Too cool and rainy weather may favor, for example, the production of fatty matter, which certainly exerts an unfavorable effect upon the aroma in smoking. There may be produced, however, still other products which are unfavorable to the aroma. Too dry weather may also interfere with the proper composition of the ripening tobacco leaves. By crossing and selection, however, varieties of tobacco may possibly be produced that even under unfavorable climatic conditions will not form much of the compounds which injure the aroma. In regard to the selection of the seed, it may be mentioned that even now some farmers go so far as to import their seed directly from Cuba each year.

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U. S. DEPARTMENT OF AGRICULTURE.

Report No. 66.

# SHEEP AND WOOL:

## A REVIEW OF THE PROGRESS OF AMERICAN SHEEP HUSBANDRY.

BY

J. R. DODGE, Special Agent.

WASHINGTON:
GOVERNMENT PRINTING OFFICE,
1900.

U. S. DEPARTMENT OF AGRICULTURE.

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# LETTER OF TRANSMITTAL.

DEPARTMENT OF AGRICULTURE,
OFFICE OF ASSISTANT SECRETARY,
*Washington, D. C., July 5, 1900.*

SIR: I have the honor to transmit for your approval, as a report for publication, a manuscript prepared by Mr. J. R. Dodge, formerly statistician of this Department, upon the sheep and wool industry in the United States. The purpose of this report, as I instructed the author, was to review the history and development of the sheep industry in this country and to trace the history of our domestic wool in particular, the variation in prices, and the nature and extent of foreign competition. It has not been possible of course in such a report to eliminate reference to tariff legislation and its general effects on this industry, nor to avoid pointing out in some degree the respective interests of wool growers and manufacturers. In doing so, however, every effort has been made to confine the discussion to the mere facts with as little of argument and theory as possible.

The author has done his work well, and I cordially recommend its publication as Report No. 66 of this Department.

Very respectfully,

J. H. BRIGHAM,
*Assistant Secretary.*

Hon. JAMES WILSON,
*Secretary.*

# LETTER OF SUBMITTAL.

WASHINGTON, D. C., *July 3, 1900.*

SIR: In fulfilling your commission to investigate the present condition of American sheep husbandry, with a concise and comprehensive review of past progress and its degree of success in meeting the demand for manufacture, I respectfully submit the following report. It touches lightly on the early history of the industry in the colonial period, briefly refers to the eventful era of Spanish Merino importation, and considers the tendencies of breeding to meet the wants of manufacture, the economies of woolgrowing, and the great change in enlargement of production and improvement of quality of mutton. It shows progressively the measure and quality of the domestic wool supply. It traces the periods of decline and revival, analyzes recent tariff changes, compares rates of duty, indicates partially the effects of the free wool era, and closes with a showing of present conditions.

Very respectfully,

J. R. DODGE,
*Special Agent.*

Hon. J. H. BRIGHAM,
*Assistant Secretary.*

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# SHEEP AND WOOL: A REVIEW OF THE PROGRESS OF AMERICAN SHEEP HUSBANDRY.

## BRIEF HISTORY OF WOOLGROWING IN COLONIAL TIMES.

The first settlers in the American colonies in Virginia, in Massachusetts, and in New York either brought sheep with them or with earliest importation of supplies from the native land. With furniture and household equipment came the loom and the spinning wheel. The matrons of the household were weavers and the daughters spinsters. The clothing of the country people was largely of domestic manufacture from wool grown on the farm.

The sheep were mainly from the countries of the settlers—England and Holland. They were of coarse-wool breeds, but not the highly improved breeds of the long and middle wools of to-day. They were of less weight, longer of limb, less compact and symmetrical of body, and of lighter fleece. Those from England were the unimproved progenitors of the mutton breeds, which have been moulded by slow degrees of patient breeding into the present forms.

It is said that the first sheep brought into the colonies landed at Jamestown, Va., in 1609. Settlement was slow and increase of sheep moderate, but in 1649 the number in Virginia was reported at 3,000. There were early importations into Massachusetts, and by 1640 the number was estimated at 3,000. The Dutch brought over sheep to New Netherlands in 1625 and again in 1630. A Swedish colony in 1663 brought 80 into Delaware. All of the colonies introduced flocks and encouraged domestic manufacture of wool.

Colonial legislatures encouraged woolgrowing and manufacture. In 1645 Massachusetts enacted a law for the encouragement of the raising of sheep; and in 1656 one was passed requiring each family to spin three pounds of wool, cotton, or flax per week for thirty weeks of the year. In the same year a skilled weaver, induced by a grant of 30 acres of land, settled in Lowell, Mass., which has since become a great center of textile industry. Virginia, a little later (1662), prohibited the exporting of wool and offered a bounty of five pounds of tobacco (Virginia currency) for every yard of cloth made in the colony. Two years later the general assembly provided for the establishment of looms and weavers in each county. The other colonies enacted laws for the encouragement of woolgrowing and manufacture.

Efforts were early made to encourage weavers and artisans to come from foreign countries and establish a germ of the later factory system by building and operating fulling mills, thus supplementing the results of domestic manufacture. They so increased in the following century that the carding, weaving, and spinning of wool and the dressing of cloth became general in all the colonies before the war of the Revolution.

As the friction between the mother country and the colonies became intense, and the colonies were ripening for the revolution, a patriotic impulse for the wearing of homespun and the discarding of English goods became general. It is said that the Harvard graduating class in 1770 appeared in black cloth of New England manufacture. Similar patriotic impulses actuated colonial officials and professional and business men, and women vied with the men in their patriotic devotion to homespun.

Societies for the promotion of agriculture sought to encourage and promote woolgrowing by essays and premiums. In 1785 a medal was offered by a South Carolina society for the first flock of Merino sheep kept in the State, but it was eight years before the first individual of that breed was imported into any of the States.

Washington was an importer of the improved English sheep. Prominent Virginians took a positive interest in the extension and improvement of sheep husbandry. There were few that were indifferent to a subject so important. Only one, as recorded in the history of the time, the eccentric John Randolph of Roanoke, was so averse to it that he expressed a willingness at any time to go out of his way a mile "to kick a sheep."

In the other colonies the public men were ever the friends of woolgrowing. It was a subject of vital interest to all, as clothing, next to food, is the greatest physical want of humanity. Cotton was scarce and high, and wool for the winter, as flax for the summer, was an ever-admitted necessity of existence. Public men, almost without exception, were favorable to the encouragement by legislation, by premium and bounty, of the manufacture of wool. Societies and a general consensus of public opinion promoted and facilitated personal effort for the extension of woolgrowing and wool manufacture. This was the situation at the time of the establishment of the National Government. There is no record of numbers of sheep, but in proportion to population they may have been nearly as numerous as at present, though not yielding as heavy fleeces. Twenty years afterwards, under the influence of the Merino excitement and a forecast of war, there were, according to the best estimates, more sheep than people, a number larger in proportion to population than at any time since; a number in 1810 as great as would be 100,000,000 for the present population; a number equal to the flocks of Australasia or those of the Plata River countries of South America at the present time.

### INTRODUCTION AND IMPROVEMENT OF THE MERINO.

The Spanish Merino is the foundation of the present fine-wool flocks of all countries. This type of sheep antedates the Christian era. Sheep were held in Spain by the king, the nobles, the clergy, and others, and their exportation was prohibited. Until the nineteenth century none could be obtained except by royal favor or by smuggling, which was very difficult. In 1765 three hundred were introduced into Saxony by royal courtesy and were the origin of the Saxon improvement. They were said to be mostly of the Escurial family, assumed to bear the finest wool. Other families were the Infantados, Paulars, Negrettis, Montarcos, Guadaloupes, and Aguirres. The Infantado was a popular breed (progenitor of most American flocks), with soft, silky, and gummy wool; the Paulars were perhaps the handsomest; the Aguirres were better covered in face and legs and the wool was more crimped than that of the Paulars; the Negrettis were tall and homely with wool still more crimped; and the Guadaloupes were tall and rather ungainly with thick crimped wool.

The French Merino had its origin in the breeding of the royal sheep folds at Rambouillet, beginning with 300 imported from Spain by royal favor in 1786. A record of the average weights of their fleeces in the last years of the eighteenth century was from 7 to 9 pounds. This was only the beginning of the improvement that produced the large forms and fleeces of later days.

There is a record of three Merinos, imported in 1793 by Mr. William Foster, of Boston, who gave them to a friend who killed them for mutton. In the first year of this century a French banker, De Lessert, sent four ram lambs to this country, only one surviving, which founded some good grade flocks for his owner, Mr. E. I. Dupont, near Wilmington, Del. In the same year Seth Adams of Zanesville, Ohio, imported a pair of Spanish sheep. In 1802 the American minister to France, Mr. Livingston, sent home two pairs of French Merinos from the royal flock at Chalons and afterwards one from Rambouillet. About 1810 he sold full-blooded ram lambs at $1,000 each and grades at very high prices. He sold the wool of full bloods at $2 per pound, of three-fourths bloods at $1.25, and of half bloods at 75 cents.

Later in the same year Colonel Humphreys, the American minister to Spain, brought home 21 rams and 70 ewes, believed to be of the Infantado family, very carefully selected, and from this importation may be traced some of the finest flocks of the present day. The Atwood strain, now in high repute, originated in a flock founded by Stephen Atwood, of Woodbury, Conn., with stock from the Humphreys importation, which have been bred in great purity to the present day. His first purchase was a ewe bought for $120.

There were small importations in 1803 and 1807. In 1809 and 1810 Mr. William Jarvis, the American consul at Lisbon, Portugal, bought

of the Spanish Junta, from confiscated flocks of Spanish noblemen, and sent to various parts of this country 3,850 Merinos. Fully a third of these were Aguirres; the remainder Escurials, Montarcos, Paulars, and Negrettis. He not only mixed his large flock, but afterwards crossed with the Saxon Merino. Before the cross the average weight of his pure-bred fleeces was 4 pounds. Randall says that 3,500 to 5,000 Spanish Merinos were imported by other persons in 1809, 1810, and 1811.

There was little excitement about the earlier importations up to 1807. Then the difficulties with England and France called attention to the necessity of providing a domestic supply of wool, the embargo intensified popular interest in the matter, and the war of 1812 shut off foreign supplies. It is not strange that prices rose to the extreme of $2.50 per pound for wool and $1,000 or more for a pure-bred sheep. After peace was declared, however, and a flood of foreign goods was admitted, they became a drug in the market at a dollar a head.

The Saxon Merinos were imported in large numbers between 1824 and 1848. During that period this very fine-wool breed had the preference, and the owners of Spanish sheep hastened to obtain a Saxon cross, which reduced the weight of fleece and weakened the constitution of the sheep. The Saxons produced the finest of wool, but they lacked constitutional vigor. Fine flocks have been kept here from that day to this, though few for years past and very few at present. In that Saxon boom their good name was injured by frauds in selling grades for pure bloods. Their failure to sustain their popularity was due mainly to the fact that the price of Saxon wool was not sufficiently high to offset the light weight of fleece.

The great Jarvis flock, in which five families were mixed, was bred, unwisely, to accommodate the manufacturers, sires of a lighter color, the Escurial chiefly, being used instead of the darker-colored or yolkier families. His sheep were more compact than the average Spanish, but much like them otherwise. Some of his ewes yeilded 4 or 4½ pounds of washed wool. This flock finally lost its identity in other breeding flocks.

The Atwood flock was the first example of patient, skillful, and long-continued breeding (from 1813 to 1830). It was built up with careful selections from the Humphreys importation, and afterwards maintained and improved by selection of individuals within the flock. In 1840 the form was Spanish slightly modified, wool short, fine, well crimped, shorter on the belly, not yet fully covering legs and head. Some of the rams had pendulous dewlaps and neck folds or wrinkles. As the Spanish Merino came into especial favor, this flock became popular, and colonies were scattered through the country, especially in New York, some deteriorating, others continuing to improve. This was a

notable beginning, worthy of all praise, but not yet was the American Merino thoroughly established as a new breed of the Merino type.

Though many breeders worked together in the improvement which has developed the most notable and valuable breed of the world, Mr. Edwin Hammond, of Middlebury, Vt., is fairly entitled to be considered the founder of the American Merino breed. He made three purchases between 1844 and 1846, of average selections from the different qualities of the Atwood flock, first breeding in three lines of subfamilies, the dark, the light, and intermediate, afterwards producing his best sheep by crossing these lines with a skill and judgment which entitle him to rank with Bakewell in the long-wool improvement in England. He changed the thin, light-boned, imperfectly covered sheep into models of fine-wool beauty, large, round, low, and strong-boned. The ewes weighed, as reported in 1863, from 110 to 140 pounds, the heaviest fleece weighing 17½ pounds. The ram "Sweepstakes," 1856, sometimes referred to as the origin of the American Merino, as a breed distinct from the old Spanish, had a weight record of 140 pounds and a fleece of 27 pounds.

The extent of the improvement is indicated by measurements made by Mr. Randall in 1861 of individuals of Hammond's flock in comparison with careful measurements in Austria of Spanish sheep at the beginning of the century: American ram, 122 pounds; Austrian Infantado, 104 pounds; American ewes, 100 to 114 pounds; Austrian Infantado, 73 pounds. The Negretti weights were still lower—ram 100, ewe 70 pounds. American measurements of length were 3 feet 11 inches to 4 feet; Austrian Infantado, 5 feet 4½ inches to 5 feet 8 inches. American girth measurements were 4 feet ¾ inch to 4 feet 4½ inches; Infantado, 4 feet 11½ inches to 5 feet. Notice the decrease in length and girth with increase of weight. The neck and legs were shortened and the width of hips was increased. The increase in weight of fleece was extraordinary.

From this initial point the subsequent development and differentiation of this great breed are sketched very concisely in the following chapter.

### BREEDING TENDENCIES IN WOOLGROWING AND THEIR EFFECTS.

Nothing is more noticeable in the history of our sheep breeding than the ever-existing tendencies to change. The flocks of one period perceptibly differ from those of ten years later. It is impossible that it should be otherwise, for change is inevitable, and in a country of such resources, enterprise, and ambition as our own this tendency to change is quickened. To meet the requirements of manufacturers for various kinds and qualities of wool, foreign breeds were successively introduced, and they found here a new environment, new conditions

of climate and feeding, which in themselves would induce changes appreciable in a few years. The desire of manufacturers for specific qualities of wool, stimulated by the caprice of fashion in fabrics, also promotes a tendency in breeding to meet such requirements. A further inducement is the ambition of enterprising breeders to make improvements and thus win reputations. While change is not necessarily improvement, the result of breeders' efforts is, on the whole, amid partial failures and successes, favorable to improvement. By going back to the first half of the century and making comparisons we find that great progress has been made—a doubling of the weight of fleece, a greater variety of wool, and much better adaptation to the requirements of manufacturers and consumers of woolen goods.

When the Merino began to assert its sway, to increase rapidly the weight of fleece, and to prove to the satisfaction of the grower that there was money in wool, the temptation was strong to breed to grease in order to give great weight to the fleece, 15 to 20 and even 30 pounds or more. As it was believed that wrinkles, loose folds of skin apparently intended for a larger sheep, would carry more wool on the larger surface, this breeding to wrinkles became a fad. The manufacturer in scouring such wool found its weight a delusion, two-thirds or more of its substance disappearing in the cleansing. He was obliged to discriminate in the price, and eventually the grower found excessive grease and great weights of fleece unprofitable and undesirable; hence wrinkles began to disappear, and sires with smoother though lighter fleeces became progenitors of the flock.

The dawning of the worsted era was observed early in the sixties. There was a great scarcity of English combing wool. England could not fill the demand, nor Canada, and elsewhere the supply was small. Our manufacturers urged the importation of mutton breeds. These sheep were brought in from Canada and from England and scattered through the country east of the Mississippi, giving positive direction to the tendency to increase of the distinctive combing wools of those days.

This did not suffice. There was still a great scarcity, and the quality was coarse. A new era was opening in the worsted industry. At the French exposition of 1867 conspicuous among the wools displayed were some of the Merino race, distinguished for softness and length of fiber, from France and from Australia, derived from French stock. The French Merino, the first of its race to become essentially a mutton sheep and a producer of combing wool of much finer quality than the English combing wool, made possible the fabrication of beautiful goods for women's wear, which gave France a lead in the manufacture of such goods which she has since retained. England could not obtain this wool, and did not attempt the manufacture of this class of goods until it was found that similar qualities could be obtained from Aus-

tralia. The French had already made much progress, of which Renoville wrote concerning the combing wools of France:

> It is to the admirable revolution in the raising of ovine animals that we owe the beautiful industry of spinning the merino combing wools. It is to this that we owe the splendor of the industries of weaving combing wool at Paris, at Rheims, at Amiens, and at St. Quentin.

Great Britain had a successful combing industry of her own. She had no Merino sheep. Combing wool was advancing in price; in 1855 it sold in London for 1s. 1½d.; in 1864 for 2s. 4d. Our own worsted manufacture had been initiated and was successful, but it consumed only 6,000,000 pounds of wool. The wools were grown in Kentucky, in Ohio to a small extent, and elsewhere. No wonder that the dissemination of mutton sheep was urged for the increase of our resources for manufacture and for the meat supply of cities. There was an existing tendency to increase the distribution of English sheep and the production of combing wool by our breeding with Merino grades.

In 1868 Mr. E. R. Mudge, United States wool commissioner, advised the "ingrafting of the French race on the American Merino" as a means of supplying a manufacture which was one of the most important in France and one that was a source of much of the exportation to this country. Specimens of these Rambouillet Merinos were introduced from time to time. They did not at first strike the fancy of breeders of American Merinos, and they did not at once gain favor, but afterwards they won their way and now have a register and are widely scattered throughout the country.

It is not strange that the promoters of the great American Merino improvement should stand aloof from a movement that, as they thought, would degrade the finest wool sheep in the world to a mutton sheep. Yet, feeling the necessity for combing wool, and finding considerable difference in length of fiber in pure-bred Merinos, a few farseeing breeders began to work for longer fiber and a larger carcass, in the direction of mutton and combing wool from the distinctively wool-producing Merino. And this was the starting point from which has been produced, on lines apparently parallel but with distinct and certain divergencies, the subbreeds, the Dickenson Delaine, Standard Delaine, Improved Delaine, National Delaine, Black Top Spanish, and Improved Black Top Merino, all with record books, all pure-bred Merinos, very widely disseminated and now among the most popular breeds in the United States.

Thus has our supply of combing wools been augmented in part from this modification of the American Merino, yielding a soft and lustrous fiber, 3½ to 5 inches in length, suitable for tissues which the coarse combing wools could not produce. This progress has been continuous and persistent during the past thirty years, and in results it has been the most beneficial of the breeding tendencies which have

marked the history of woolgrowing. This course of breeding has given a supply for manufacturing competition with France, in goods requiring much skilled labor in proportion to weight of material, which no dissemination of English breeds could accomplish, and demonstrates the wisdom of the patient breeders who have worked a lifetime to accomplish this result.

The other line of development of combing wools, by increase of pure and crossbred English sheep, has run parallel with the delaine improvement of the Merino. It has been steadily progressive, constantly increasing the supply of coarse combing wools, making the worsted industry nearly independent of foreign wools of class two of the customs schedule. It has also enlarged the supply of material for flannels and certain kinds of cloths from the Down breeds.

In the States east of the Mississippi the mutton breeds have gradually gained a predominance. The southern sheep are always mainly of this class. As population increased in the Ohio Valley meat became more important than wool, and all the mutton breeds were disseminated, taking the place of Merinos, and though fewer in number the average value of sheep in this district has been nearly doubled in the last thirty years from advance in size and quality.

The Southdown, Cotswold, and Leicester were the first to invade this region, followed by the newer Down breeds. The prolific character of the Dorsets later claimed attention from producers of lambs, and twelve years ago they were introduced, and have been distributed in 27 States, 9,000 being registered in the Dorset Sheep Breeders' Association of America. The wool of the Dorset is valuable, strong, white, and nicely crimped. Its scoured fleece is heavy, the loss in scouring being light. The grade Dorset is prolific and profitable in lamb production.

The largest and one of the oldest English breeds was introduced very sparingly until the other mutton breeds had been widely distributed, but in recent years it has become so numerous that a Lincoln Association has been formed to represent it and preserve its purity. The original Lincoln, like the other long wools, was improved by Leicester crossing, diminished in size, improved in form, relieved of coarseness, and increased in aptitude for flesh taking, with finer wool of the lustrous class especially adapted for use in a valuable and desirable class of worsteds. This sheep, so long popular for wool as well as mutton in New Zealand and other Australian colonies, and later in Argentina, has for similar reasons been found desirable here, not only in the farm districts but on the ranges. This breed is largely the basis of the frozen-mutton trade which, in 1897, amounted to 144,657,184 pounds from New Zealand, and 209,172,339 pounds from Australasia altogether. The Argentina frozen-mutton trade is also very large.

A note from Mr. H. A. Daniels, Elva, Mich., secretary of the

Lincoln Association, states "that Michigan contains more Lincolns than any other State—from 4,000 to 5,000." They are scattered through New York, Ohio, Virginia, Missouri, and the Rocky Mountain area. Mr. Daniels reports large numbers of cross-breds on the range, "as the Lincoln has proved the best for crossing on range ewes of Merino descent of any breed, the same as they have been in Argentina." He refers to the large flock of registered Lincolns from England established last year by Colonel Massey, of Fort Logan, Colo.; to one of several hundred purchased in Michigan and Ontario by Forbes Brothers of Boston, and other large pure-bred flocks, as showing the present popularity and rapid dissemination of this valuable breed.

As a result of these continuous tendencies toward combing wools, both fine and coarse, Merino and English, worsted wools now largely predominate in the domestic wool supply. The Merino and English types of sheep are nearly divided as to numbers, the former predominating in the range country, the latter in farming States.

At the present time the tendency of breeding is toward increase of Merinos. The relative scarcity of wools of class one has been apparent for a year or two throughout the world, and in the immediate future there will doubtless be an increase of this breed. This tendency is manifest in this country in all wool-growing districts, even in the Ohio Valley, where mutton sheep predominate and meat is a prime consideration. A letter from Professor Plumb, director of the experiment station connected with Perdue University, Lafayette, Ind., states that the tendency of breeding there is toward the Merino, though the Rambouillet has preference over the American Merino, not losing sight of the value of the carcass while aiming to increase the quantity of fine wool.

The French type will continue in popularity, and the Delaine breeds will be disseminated more generally than at present; and, while clothing wool may increase, it is evident that the value of the mutton, in connection with wool, is not likely to be lost sight of, even in the breeding of the Merino. In breeding for fine clothing wools, plumpness and symmetry will be preferred, rather than wrinkles and grease, and smoothness of outline and thrift of growth will be desirable characteristics.

Our climate is favorable to the highest ovine development. Foreign breeds have been easily acclimated and manifestly improved. It is certain that the American sheep has no superior in any woolgrowing country, in constitutional vigor and strength of wool fiber. No other wools make more durable and intrinsically valuable clothing. American wool consumption should be mainly of American production. Manufacturers know that their prosperity depends upon a full domestic wool supply, and will cooperate with the growers in encour-

aging the production of wool to meet all ordinary requirements of clothing, both cloths and worsteds.

### INCREASE OF MUTTON SHEEP.

In the colonial period the sheep were all of the coarse-wool type, brought with the settlers from the countries of their nativity. They were the unimproved original stock, the progenitors of the present improved English breeds. Later Washington and other fathers of the Republic brought in individuals representing the early breeding improvement in Europe. No Merinos came in until after the organization of the National Government. The Merino importation in the present century and the establishment of the American Merino breed in a half century of breeding to build up an American wool industry so popularized that breed as to give it a largely predominating influence forty years ago. Thirty years ago more than four-fifths of all the sheep in the country were either pure-bred or grade Merinos. There were a few Downs and specimen flocks of various long-wool breeds, small in number, in the Middle States and in the Ohio Valley and scattered sheep of the old coarse-wools in the South. Kentucky had the largest number of the long-wools. There was some importation from England and more from Canada. In Texas and New Mexico there were some Mexican sheep of Spanish origin, degenerated and almost reverted to a wild state. Their fleeces, coarse and hairy, weighed only a pound or two. Possibly all these together were not more than 15 per cent of the whole. There is no exact census of the coarse-wooled sheep of that period, those having no Spanish Merino blood, yet the almost universal predominance of that type and the character of the wool appearing in the markets of those days will amply sustain this view as conservative and sufficiently accurate.

For at least thirty years there has been a tendency—strengthening as the years roll on and helped by the steady and rapid increase of population demanding meat—toward increase of coarse-wool sheep, enlargement of mutton production. Even earlier a greater need of worsted wools was felt, and the initiative was taken toward their supply. This transformation of flocks would have been more rapid but for the discovery that Merino wools of long fiber could be combed, which stimulated the adaptation of special machinery by manufacturers and the gradual lengthening of Merino fiber by breeding on the part of the growers. The writer of this as early as 1862 urged that the American farmers should seek a profit in mutton and wool rather than in wool alone; that the great want of the world was "a strong, serviceable, long-fibered combing wool, and a great deal of it." In 1866 an estimate submitted to the revenue commission made the value of the annual product of worsteds, exclusive of delaines, $10,000,000.

In 1867 Mr. Mudge, commissioner of wools and woolens at the Paris

exhibition, said to the woolgrowers of this country "that there is a field more vast than their imagination can take in in the expansion of the worsted industry." Under such inducements the flocks of mutton sheep increased in all parts of the country, though Merino improvement was still the predominant feature in sheep husbandry in Vermont, New York, Pennsylvania, Ohio, Michigan, and elsewhere, and the great flocks of the Territories became Merino grades of a high order of improvement. But the great breeding flocks were improved largely in the direction of Delaines, producing a fine combing wool of gradually increasing length of fiber.

During the past ten years the increase of mutton breeds has been more rapid than ever. They predominate in all the older States east of the Rocky Mountains. In the mountain States many have been introduced in recent years, sires of English breeds being procured to produce cross-bred mutton in place of wool alone. In this way the breeders hoped to turn their flocks into mutton sheep and obtain a profit they could not get from wool. It seemed feasible, but so many were thrown upon the markets as meat that prices fell and discouragement continued. In the central West numbers of sheep have been greatly reduced, yet they are nearly all of the mutton type.

Mr. Avery, of Mauger & Avery, Boston, than whom no dealer in wool has better facilities for knowing the character of American flocks, writes that at least 70 per cent are medium cross-bred wools, and possibly 80, and the remainder Merino or its grades. He estimates the wool of the ranges as 30 per cent medium crossbred and 70 per cent Merino. Other dealers, in Boston and Philadelphia, furnish information showing the great predominance of coarse wools east of the Mississippi.

Messrs. Hecht, Liebmann & Co. of Boston, who deal very extensively in "Territory" wools, state that most of their wool is Merino, much of it pure or nearly so; in rarer cases it is crossed once, sometimes twice, with Lincolns, Shropshire, or other coarse-fibered English stock. They say:

> The wools we receive from eastern Oregon, California, Nevada, western Idaho, southern Utah, and Texas seem to be as purely Merino as it is possible to grow them, without producing unmarketable mutton. On the other hand, wools received from certain parts of Oregon, southeastern Idaho, northern Utah, and western and northern Wyoming are distinctly crossbred, and show, from year to year, a gain in English blood. We do not receive any wool that is wholly of English blood, except an occasional ram fleece.

It appears probable, from information derived from many sources, that about half of the sheep of the country are now of English breeds or grades in which that blood predominates.

Those who have watched the great Western markets have seen abundant evidence of higher appreciation of mutton than formerly, in active markets and higher prices. During the present season the

average price of mutton in the Chicago market has ranged higher than that of beef, and at times the quotations for prime native wethers have been higher than for extra prime steers.

A noticeable feature of the mutton trade has been the demand for Colorado lambs. It was discovered that the Mexican lambs improved by crossbreeding, and fed a few months in winter with corn and alfalfa made meat of high quality, which has become so popular that it is sought as a delicacy by managers of hotels of the seaboard cities from Boston and New York to Florida. These lambs sell in Chicago for $7.50 to $7.75 per 100 pounds. The business of feeding has been very profitable, and much money has been made in it. Some feeders have had thousands in their yards at a time, and some young men with small means and a little credit with local banks have made handsome profits. Clay, Robinson & Co. of Chicago estimate the annual output of these lambs fed in Colorado at 350,000, with as many more under similar feeding at other points. At $6 per head, this would make a total of $4,200,000 for this peculiar development of mutton production. The preferable live weight of these lambs is about 80 pounds, which is not far from the average.

The mutton breeds are very prolific, and the number of lambs with proper care is 100 per cent of the number of ewes. Always a large proportion of the lamb crop of the farming districts and not a few in ranch districts are every season consumed locally as spring lambs, or appear in markets through the year, being usually known as lamb until a year old.

An indication of the rapid increase and large volume of marketing of sheep is found in the records of receipts of four principal Western markets, at different periods, as follows:

*Number of mutton sheep received at principal Western markets at different periods.*

| | 1870. | 1880. | 1890. | 1899. |
|---|---|---|---|---|
| Chicago | 349,853 | 335,810 | 2,182,667 | 3,682,832 |
| Kansas City | ..... | 50,611 | 535,869 | 953,241 |
| Omaha | ..... | ..... | 156,186 | 1,066,319 |
| St. Louis | 94,477 | 205,969 | 358,496 | 432,566 |

Here is an increase in thirty years from less than 500,000 to more than 6,000,000, and over 5,000,000 were slaughtered in these four cities. Other cities in the West slaughter considerable numbers, the great seaboard cities kill large numbers, besides consuming refrigerated carcasses from the West, and every town and village in the country has a market for live sheep and lambs. On nearly a million farms and ranches where sheep are grown, mutton is a prominent resource for meat consumption.

A similar change in distribution of mutton sheep has been observed in all wool-growing countries. A strong inducement has been found

in the demand for mutton in Great Britain, which has given rise to the frozen meat trade of New Zealand and Argentina. Heavy importations of English mutton sheep have been in progress in those countries for years, until nearly half their flocks are crossbred. Messrs. Helmuth, Swartze & Co., of London, in reporting the relative proportion of crossbred and merino wools, show an increase of the former from 17.7 per cent in 1888 to 44.6 per cent in 1898 in the colonial and Plata River wools, as given in the following statement in millions of pounds of clean wool:

*Relative increase and decrease of crossbred and Merino wool.*

| Year. | Crossbred. | | Merino. | | Total millions of pounds. |
|---|---|---|---|---|---|
| | Millions of pounds. | Per cent. | Millions of pounds. | Per cent. | |
| 1888 | 70 | 17.7 | 325 | 82.3 | 395 |
| 1892 | 98 | 19.6 | 402 | 80.4 | 500 |
| 1897 | 232 | 39.6 | 354 | 60.4 | 586 |
| 1898 | 248 | 44.6 | 308 | 55.4 | 556 |

The result of so radical a change throughout the world has caused the relative appreciation of merino wool. There is in all markets a comparative scarcity of fine wool, and a demand for increase to which breeders are now responding.

Under present conditions, however, the production of mutton in this country will continue to be profitable, and should be, in some of its branches, one of the important rural industries of our oldest and most populous States.

The present distribution of mutton sheep is more general than ever before. They have invaded the pastures so long sacred to the development of the American Merino in Vermont, and the strongholds of Merino breeding in New York, Ohio, and Michigan. They have nearly driven out the fine-wool competition in Indiana and Illinois, and taken possession of sheep pasturage on the meat-producing prairies of the Missouri Valley. This movement has long been in progress. In the recent period of depression, when growers would fain have ceased to think of sheep as a wool-bearing animal, the mutton sheep hastened its migration to the ranges of the Rocky Mountains, and essayed the muttonizing of Merino flocks by cross-breeding. So active and persistent was this effort to get some profit from meat, where wool failed to pay the cost of shearing and growing, that in the entire range country 30 per cent of flocks were of mutton breeds, according to the estimate of Mauger & Avery, wool dealers of Boston, who are familiar with the stocks of the greatest wool markets in the country. The same authority thinks that in the farming States 70 and perhaps 80 per cent of the wool is from sheep in which the

blood of the English breeds predominates. This would indicate a nearly equal division of the Merino and English races in the United States.

### THE DOMESTIC WOOL SUPPLY.

The use of wool is coincident with the use of clothing. The first white settlers of this country brought with them the domestic loom and spinning wheel. For more than a century and a half, household manufacture held universal sway. The fulling mill supplemented its operations and suggested the factory to come. This was the condition when the United States Government went into operation and for some time thereafter.

The consumption of wool in this country has always been relatively large. Prior to the beginning of the factory era, however, consumption averaged not more than 3 pounds per capita of population. Fifty years ago the requirement had risen to 4 pounds. As wealth increased and styles of fabrics multiplied, the uses of wool enlarged, until, at the present time, with velvet tapestries for the home and luxuries in worsted for its presiding genius, the requirement per head has risen to about 8 pounds. No other people use so much wool, as also none use so much cotton. The wool of the world will scarcely suffice for 2 pounds annually for each of its inhabitants. Our rate of consumption has doubled in half a century, but it has not increased in the last ten years and may not increase in the future.

About two-thirds of our present mill consumption is supplied from domestic sheep, and a larger proportion very soon will be, as numbers of sheep are rapidly increasing. Including imported manufactures, the domestic supply is now fully half the entire consumption of wool products and promises soon to be two-thirds. Between 1880 and 1890 the proportion of domestic wool was larger, being nearly six-tenths of all needed. In value the proportion was still larger, the imported wools for manufacture being mostly of a much lower quality, largely used for blankets and carpets. There should be no difficulty in so enlarging the domestic supply as to meet the requirements of consumption of nearly all the cloths, worsteds, knit goods, and at least the better class of carpets. The only practical limitation of a full supply of everything is from economic causes.

We have already nearly all the improved breeds of the world, and a great variety of the climates and grasses of the world. If we do not produce much of the finest Saxony wool it is because heavier fleeces are more profitable. Wool of this class has compared favorably with the finest ever produced in Saxony, and flocks of this class are still in existence, some of the finest being in Washington County, Pa. Our Mexican sheep yield a typical carpet wool, but crossed with the Merino a heavier fleece of more valuable wool is produced, and growers find profit in the improvement. When we produce 500,000,000

pounds or more of domestic wool, some of the coarsest fleeces and the least valuable pieces of sorted fleeces can supply the material for the better class of carpets, and the coarsest of the wools of lower civilization and unimproved agriculture may be received, under proper safeguards, to supplement the wants of the carpet industry.

For strength and durability American wools are unsurpassed, and make more durable clothing than the average product of any other nation. In this respect they are superior to Australian wools, which suffer loss of strength from the effects of a hot and dry climate. The flocks of those colonies have been recruited from American Merinos largely, and of late many are crossed with English Lincolns and other breeds to meet the demands of fashion for lustrous wools. This in part, but mainly the light shrinkage, owing to the smaller quantity of grease to be eliminated, makes the higher prices of Australian wool as compared with heavy-shrinking merino wool. The method of marketing, sorting by the skirting process, has also added much to prices of these wools for ten years past.

American sheep have long been appreciated abroad. As early as 1851, at the London World's Exhibition, four prize medals were given to American sheep, and at the Hamburg International Exhibition of 1863, in competition with representatives of the finest flocks of Europe, two first-class premiums were awarded to Merinos from Vermont. Ever since then our American Merinos have been drafted into the service of countries in wool-growing development, notably in the Australian colonies and in South America.

The enumeration of sheep was not made by the census until 1840, when the number reported was 19,311,000. For twenty years there was little increase. In 1850 the number given was 21,773,000, and only 22,471,275 in 1860. Prior to 1840 no very accurate estimates are available. There had been a great boom in sheep in the early years of the century, when Spanish Merinos began to be imported. Independence of foreign wool became an intense and pervading feeling in the years preceding the war with England, and a determined effort for a full domestic supply was made. An estimate for 1810 places the number of sheep at 10,000,000, and the value of manufactures—domestic manufactures, as only a few small factories were then in existence—was estimated at $25,000,000. If correct, it must be that prices of goods were very high. After the war of 1812 the sheep industry was nearly wiped out as the result of a deluge of cheap woolen goods, and it was several years before the numbers of 1810 were again attained.

Between 1860 and 1870 a very rapid advance was made, from about 22,000,000 to possibly 42,000,000, followed by a decline in the later years of the decade to 31,000,000. Annual estimates were made by the Department of Agriculture, not including the mountain areas till nearly the close of the decade, when statistical service was organized

in the great ranch districts. The figures were therefore not complete in those years. After this disturbed and fluctuating record the estimates became more reliable and the development more uniform. The following table presents this record, with estimates of wool produced, from 1871 to the present time:

*Number, average value, and total value of sheep in the United States, and amount of wool produced, 1871–1900.*

| Year. | Number of sheep. | Average value. | Total value. | Pounds of wool. |
|---|---|---|---|---|
| 1871 | 31,851,000 | $2.32 | $74,085,837 | 153,000,000 |
| 1872 | 31,679,300 | 2.80 | 88,771,197 | 150,000,000 |
| 1873 | 33,002,400 | 2.96 | 97,922,350 | 158,000,000 |
| 1874 | 33,938,200 | 2.61 | 88,690,669 | 170,000,000 |
| 1875 | 33,783,600 | 2.79 | 94,320,652 | 181,000,000 |
| 1876 | 35,935,300 | 2.61 | 93,666,818 | 192,000,000 |
| 1877 | 35,804,200 | 2.26 | 80,892,683 | 200,000,000 |
| 1878 | 35,740,500 | 2.26 | 80,603,062 | 208,250,000 |
| 1879 | 38,123,800 | 2.07 | 79,023,984 | 211,000,000 |
| 1880 | 40,765,900 | 2.21 | 90,230,537 | 232,500,000 |
| 1881 | 43,576,899 | 2.39 | 104,070,861 | 240,000,000 |
| 1882 | 45,016,224 | 2.37 | 106,595,954 | 272,000,000 |
| 1883 | 49,237,291 | 2.53 | 124,365,835 | 290,000,000 |
| 1884 | 50,626,626 | 2.37 | 119,902,706 | 300,000,000 |
| 1885 | 50,360,243 | 2.14 | 107,960,650 | 308,000,000 |
| 1886 | 48,322,331 | 1.91 | 92,443,869 | 302,000,000 |
| 1887 | 44,759,314 | 2.01 | 89,872,839 | 285,000,000 |
| 1888 | 43,544,755 | 2.05 | 89,279,926 | 269,000,000 |
| 1889 | 42,599,079 | 2.13 | 90,640,269 | 265,000,000 |
| 1890 | 44,336,072 | 2.27 | 100,659,761 | 276,000,000 |
| 1891 | 43,431,136 | 2.50 | 108,397,447 | 285,000,000 |
| 1892 | 44,938,365 | 2.58 | 116,121,270 | 294,000,000 |
| 1893 | 47,273,553 | 2.66 | 125,909,264 | 308,153,000 |
| 1894 | 45,048,017 | 1.98 | 89,186,110 | 298,057,384 |
| 1895 | 42,294,064 | 1.58 | 66,685,767 | 309,748,000 |
| 1896 | 38,298,783 | 1.70 | 65,167,735 | 272,474,708 |
| 1897 | 36,818,643 | 1.82 | 67,020,942 | 259,153,251 |
| 1898 | 37,656,960 | 2.46 | 92,721,133 | 266,720,684 |
| 1899 | 39,114,453 | 2.75 | 107,697,630 | 272,191,330 |
| 1900 | 41,883,065 | 2.93 | 122,665,913 | [1] 290,000,000 |

[1] Estimated.

In fourteen years from 1871 the increase was about 60 per cent. From 1885 to 1889 numbers declined, increased again until 1893, then fell off again until 1897. Increase is now regular, with the likelihood of reaching a higher figure than has been heretofore attained.

Increase in numbers of sheep has not always represented the increase of the domestic wool supply. Improvement by breeding and by better care has more than doubled the weight of fleece. The census of wool is probably not so accurate as that of sheep, but a comparison of the different enumerations shows a steady and rapid increase in weight, in dividing the reported quantity of wool by the number of sheep.

The steady increase in the weight of fleeces is the result of a stronger infusion of Merino blood in clothing-wool flocks, and the improvement in Mexican and other low-grade sheep by the use of sires of English mutton breeds. Better care and feed have also increased the weight of fleece. As indicated by the census enumeration, the average weight has been 1.9 pounds in 1840, 2.4 in 1850, 2.7 in 1860, 3.5 in 1870, 4.4 in 1880, and 4.8 in 1890.

While the census returns of wool are doubtless somewhat low, the

averages indicate an increase that is well understood by woolgrowers. Expert investigation shows somewhat larger averages, which have quite regularly increased until the present average comes within a small fraction of 6 pounds per fleece. It should be understood that the fleeces shorn from the sheep on the farm do not constitute the full domestic wool supply. The millions of sheep and lambs slaughtered are either shorn before slaughtering or the pelts afterwards furnish a considerable quantity of pulled wool, so that the entire year's supply of wool is taken from a much larger number of sheep than any census or assessors' enumeration gives.

The distribution of sheep at the present time is indicated by the following estimates of numbers and average values in January, 1900:

*Numbers and values of sheep, January 1, 1900, by States and Territories.*

| States and Territories. | Number. | Average value. | Total value. |
|---|---|---|---|
| Maine | 254,027 | $3.10 | $787,484 |
| New Hampshire | 79,072 | 3.19 | 252,239 |
| Vermont | 169,259 | 3.61 | 611,363 |
| Massachusetts | 40,194 | 4.55 | 182,883 |
| Rhode Island | 10,608 | 3.86 | 40,974 |
| Connecticut | 31,808 | 3.90 | 124,194 |
| New York | 846,165 | 4.07 | 3,448,122 |
| New Jersey | 42,722 | 4.34 | 185,584 |
| Pennsylvania | 814,322 | 3.60 | 2,928,302 |
| Delaware | 12,592 | 3.67 | 46,269 |
| Maryland | 138,177 | 3.51 | 485,553 |
| Virginia | 376,918 | 3.09 | 1,164,676 |
| North Carolina | 235,260 | 1.62 | 379,945 |
| South Carolina | 61,217 | 1.70 | 104,069 |
| Georgia | 294,826 | 1.76 | 518,893 |
| Florida | 76,074 | 1.69 | 128,870 |
| Alabama | 171,799 | 1.53 | 262,767 |
| Mississippi | 215,748 | 1.56 | 335,490 |
| Louisiana | 113,205 | 1.58 | 179,203 |
| Texas | 2,416,721 | 1.92 | 4,634,063 |
| Arkansas | 108,957 | 1.67 | 181,795 |
| Tennessee | 251,735 | 2.37 | 596,485 |
| West Virginia | 426,814 | 3.19 | 1,363,244 |
| Kentucky | 549,832 | 3.01 | 1,656,094 |
| Ohio | 2,839,690 | 3.71 | 10,535,250 |
| Michigan | 1,389,073 | 3.58 | 4,972,882 |
| Indiana | 677,905 | 4.00 | 2,713,993 |
| Illinois | 637,719 | 3.97 | 2,532,383 |
| Wisconsin | 744,656 | 3.65 | 2,716,505 |
| Minnesota | 419,218 | 3.18 | 1,333,113 |
| Iowa | 619,476 | 4.02 | 2,487,816 |
| Missouri | 597,619 | 3.10 | 1,854,711 |
| Kansas | 275,118 | 3.04 | 835,534 |
| Nebraska | 322,057 | 3.39 | 1,090,807 |
| South Dakota | 381,882 | 3.29 | 1,257,156 |
| North Dakota | 374,110 | 3.16 | 1,183,683 |
| Montana | 3,884,179 | 2.84 | 11,017,474 |
| Wyoming | 2,840,190 | 3.51 | 9,964,806 |
| Colorado | 2,185,327 | 2.86 | 6,250,036 |
| New Mexico | 3,073,439 | 2.17 | 8,622,362 |
| Arizona | 1,024,480 | 2.34 | 2,393,581 |
| Utah | 2,370,988 | 2.59 | 6,150,330 |
| Nevada | 657,773 | 2.91 | 1,914,120 |
| Idaho | 2,658,662 | 2.80 | 7,444,254 |
| Washington | 790,217 | 3.13 | 2,470,218 |
| Oregon | 2,446,695 | 2.67 | 6,532,676 |
| California | 2,001,501 | 2.85 | 5,710,282 |
| Oklahoma | 33,094 | 2.52 | 83,380 |
| Total | 41,883,065 | 2.93 | 122,665,913 |

A great change has occurred in the distribution of sheep in thirty years. In 1870 the mountain range country was just emerging from

the control of the Indians, and, with the Pacific coast and Texas, contributed only 22 per cent to the Department estimates of 1871; now the above table gives to this Western range section about 65 per cent of all, or more than 27,000,000 sheep. Then Texas was beginning to make progress in sheep husbandry, which was so rapid that in 1884 the record made an aggregate of nearly 8,000,000, the highest ever made by that or any sister State. That of last January was 2,416,721, a figure exceeded by New Mexico, Montana, Wyoming, Idaho, and Oregon.

These facts indicate the relative decline of sheep husbandry in the farming States. The free pasturage of the great range country handicapped the industry on farm lands, especially the woolgrowing branch. Just as wheat growing gradually receded westward, and cattle raising declined, first east of the Alleghenies and afterwards appreciably in the Ohio Valley, woolgrowing almost disappeared from the farms, while mutton production lingered in the blue-grass section and other regions of fat pasturage, and the raising of early lambs retained a footing among farmers skilled in this branch of meat making. A few of the skilled and experienced breeders of Vermont, New York, Pennsylvania, and Ohio continued the development of pure-bred Merinos for the improvement of the flocks of the range country, and those of South America and Australia. With increasing demand for mutton, the flocks of the farming States were gradually modified by a larger infusion of the blood of the English breeds. Thus the balance of distribution was disturbed, notwithstanding some advantages in high breeding and nearness to mutton markets.

The Central West was long a stronghold of woolgrowing. It gave way to powerful far Western competition slowly, holding its position tenaciously, and yielding only as other industries and interests demanded recognition and commanded better profit. The following statement compares the present with the distribution of 1871:

*Number and value of sheep in Central West in 1871 and 1900 compared.*

| States. | 1871. | | | 1900. | | |
|---|---|---|---|---|---|---|
| | Number. | Average value. | Total value. | Number. | Average value. | Total value. |
| Kentucky | 904,300 | $2.53 | $2,287,879 | 549,832 | $3.01 | $1,656,094 |
| Ohio | 4,611,000 | 2.26 | 10,488,660 | 2,839,690 | 3.71 | 10,535,250 |
| Michigan | 3,072,800 | 2.23 | 6,852,344 | 1,389,073 | 3.58 | 4,972,882 |
| Indiana | 2,103,000 | 1.82 | 3,822,000 | 677,905 | 4.00 | 2,713,993 |
| Illinois | 1,424,000 | 1.98 | 2,819,520 | 637,719 | 3.97 | 2,532,383 |
| Wisconsin | 1,056,000 | 2.44 | 2,576,640 | 744,656 | 3.65 | 2,716,505 |
| Minnesota | 140,000 | 2.22 | 310,800 | 419,218 | 3.18 | 1,333,113 |
| Iowa | 1,822,700 | 1.71 | 3,116,817 | 619,476 | 4.02 | 2,487,816 |
| Missouri | 1,578,200 | 1.61 | 2,540,902 | 597,619 | 3.10 | 1,854,711 |
| Total | 16,742,000 | 2.08 | 34,815,562 | 8,475,188 | 3.58 | 30,802,747 |

In 1871 the estimated number of sheep in the country was 31,851,000; in 1900, 41,883,065. The proportions of these States at the two dates

are respectively 52.6 and 20.2 per cent. And the numbers in these States were by no means highest in 1871. Ohio had 7,000,000 a few years earlier. Although there are little more than half the number now that was reported in 1871, it is noticeable that the total value is greater now than then. This is only in part because of increase in average value of sheep in the whole country from $2.32 in 1871 to $2.93 in 1900. The increased average value of the sheep in the central West is largely due to increase in the number of heavy mutton sheep and the value of pure-bred heavy Delaine Merinos. The decrease in numbers has only one exception—Minnesota, which in 1871 had very few farm animals of any kind. There is no reason why the flocks of this section should not be increased, not for wool alone, but for mutton and wool, and the tendency is now strongly in that direction.

There is no doubt of the ability of our woolgrowers to produce a full supply of clothing and worsted wools. Of this the manufacturers have long been satisfied. Thirty years ago a president of the Wool Manufacturers' Association expressed his opinion that "the consumption of American wool, now about 125,000,000 pounds, will in six years aggregate more than 300,000,000 annually." It was not accomplished in six years, but in 1884 the supply reached that figure. This desire for a full domestic supply on the part of wise and far-seeing manufacturers was founded on the superior qualities of American wool, and also on the necessity of independence of foreign wool markets. Foreign manufacturers are compelled to depend on imported wools mainly, to scramble for supplies in all the woolgrowing countries of the world. Our manufacturers realize the advantage of nonparticipation in this competitive quest on antipodal continents and the islands of distant seas for wools, none of which are better than our own, and most of which are weaker in fiber and of less durability. Thirty-four years ago, at the very beginning of the era of improvement by breeding and better care, a committee of the National Association of Wool Manufacturers, consisting of the most experienced and successful manufacturers of the United States, said in a report:

> In a class of fabrics entering more largely, perhaps, than any others into general consumption, that of flannels, their superiority, due principally to the adaptation of the common wools of this country, their strength and admirable qualities, is so marked as almost to exclude the foreign flannels. American fancy cassimeres compare favorably in finish, fineness, and strength with those imported. Our delaines, owing again in a great measure to the excellence of our Merino combing-wool, surpass the fabrics of Bradford at the same price. The excellence of American shawls was admitted at the great exhibition at London.
>
> It has been the experience of all nations that the domestic supply has been the first and always the chief dependence of its manufactures, and the peculiar character of the material has impressed itself upon the fabric which each country has produced. Thus, in the fine wools of Saxony and Silesia we have the source of German broadcloths; in the combing-wools of England the worsteds of Bradford, and in the long Merino wools of France the origin of the flannels and cassimeres. The peculiar

excellencies of Merino wools have given origin to our flannels, our cassimeres, our shawls, and delaines, and they give soundness and strength to all the fabrics into which they enter.

Since that time the delaine improvement has been remarkable, the Rambouillet, or French Merino, has become popular, the Lincolns and Cheviots have been added to the Leicesters, Cotswolds, and the Down breeds, the stocks of the mutton type have become more numerous, and even the fat-tailed Tunis has a footing among our breeds, which now include nearly all worth noting in the world, so that our wools are greater in variety than ever before. Nearly thirty years ago the writer said of the Rambouillets: "The introduction of these regenerators, which have proved so efficient in Australia and Buenos Ayres, might well again be essayed." The better care and better feed that is now bestowed on all our farm animals extends to sheep and affects favorably the character of the wool. This liberal and systematic feeding produces a uniform, sound, and healthy fiber.

Mr. E. B. Bigelow, the first president of the Manufacturers' Association, stated "that the card-wool industry constituted the larger part, probably four-fifths of the whole," and that "the principal hindrance to the rapid extension of this branch of manufacture is the limited supply of raw material," and that "there is nothing that would give such an impetus to the manufacture of worsted fabrics in this country as a full supply of home-grown long combing-wools." The introduction of the mutton breeds above mentioned and their wider dissemination has done much to remedy this deficiency; but the introduction of the French Merino and the great improvement wrought by selection and breeding of our Delaine Merinos, which are differentiated now in fixed characteristics and established as distinct breeds with books of record, has given us a wealth of home-grown material for worsteds such as no other country enjoys.

The supply of wool for consumption is made up of the domestic product and net importation, or imports minus exports. An approximate estimate for the decade between 1840 and 1851 is 60,000,000 pounds, or 3 pounds per capita; for the decade between 1850 and 1861 about 90,000,000, or about 3½ pounds per capita. For the four decades since 1860 annual estimates of sheep and wool have been made, from which the following statement of supply has been made:

*Domestic and foreign wool supply of the United States, by decades, 1861–1900.*

| Fiscal years. | Domestic. | Foreign. | Total. |
|---|---|---|---|
| | *Pounds.* | *Pounds.* | *Pounds.* |
| 1861-1870 | 1,387,586,407 | 501,611,132 | 1,889,197,539 |
| 1871-1880 | 1,861,226,971 | 640,916,638 | 2,502,143,609 |
| 1881-1890 | 2,805,850,348 | 889,005,571 | 3,694,855,919 |
| 1891-1900 | 2,831,090,691 | 1,614,052,056 | 4,445,142,747 |

This table marks the progress of woolen manufacture and shows that more than twice the quantity of wool manufactured in the sixties is now required and that the mill consumption has advanced per capita from 5.4 to 6.4 pounds.

The foregoing summary gives the net importations by decades for forty years. For the last ten years more detail is desirable, and the following table gives the annual importation according to the tariff classification, showing the proportion of clothing, combing, and miscellaneous cheaper wools:

*Amounts, kinds, and values of wool imported into the United States, 1891–1900.*

| Year ended June 30— | Clothing wools. | | Combing wools. | | Carpet and other similar wools. | | Total. | |
|---|---|---|---|---|---|---|---|---|
| | Pounds. | Value. | Pounds. | Value. | Pounds. | Value. | Pounds. | Value. |
| 1891 .... | 32,230,935 | $6,919,913 | 6,667,023 | $1,551,490 | 90,405,690 | $7,759,969 | 129,303,648 | $18,231,372 |
| 1892 .... | 50,262,796 | 9,523,773 | 5,826,574 | 1,368,654 | 92,581,282 | 8,795,681 | 148,670,652 | 19,688,108 |
| 1893 .... | 43,311,565 | 7,876,676 | 6,736,201 | 1,466,641 | 122,386,072 | 11,720,863 | 172,433,838 | 21,064,180 |
| 1894 .... | 10,685,496 | 1,748,359 | 1,548,505 | 399,875 | 42,918,584 | 3,959,204 | 55,152,585 | 6,107,438 |
| 1895 .... | 87,151,522 | 13,335,602 | 13,476,735 | 2,637,581 | 105,405,649 | 9,583,238 | 206,033,906 | 24,565,421 |
| 1896 .... | 117,233,440 | 19,448,471 | 15,756,318 | 3,509,736 | 97,921,715 | 9,493,035 | 230,911,473 | 32,451,242 |
| 1897 .... | 200,759,079 | 34,281,656 | 37,951,490 | 7,187,620 | 112,141,457 | 11,773,915 | 350,852,026 | 53,243,191 |
| 1898 .... | 45,442,987 | 7,969,611 | 4,320,873 | 859,599 | 83,031,342 | 7,954,482 | 133,795,202 | 16,783,692 |
| 1899 .... | 12,976,999 | 1,948,954 | 2,155,419 | 587,061 | 61,603,791 | 5,786,882 | 76,736,209 | 8,322,897 |
| 1900 .... | 37,404,243 | 8,009,985 | 12,631,283 | 2,638,721 | 105,882,929 | 9,617,230 | 155,918,455 | 20,265,936 |

This makes an importation in ten years of 1,659,807,994 pounds, of which about one-half was received in a little more than three years as free wool, twice as much as the usual average under the dutiable schedules. The worst aspect of this abnormal increase is the large proportion of clothing and combing wools under the law of 1894, more than two-thirds of all the receipts for ten years coming during this period. These are the wools that compete most seriously with the domestic product.

To show the amount of wools imported at the present time and the countries from which they are imported the following statement covers imports of clothing wools, or those of the Merino type, for the fiscal year ended June 30, 1900:

*Amounts and values of clothing wools (class 1) imported in fiscal year ended June 30, 1900, by countries from which imported.*

| Countries. | Amount. | Value. |
|---|---|---|
| | *Pounds.* | |
| United Kingdom | 13,131,387 | $2,602,068 |
| France | 109,196 | 13,998 |
| South America | 12,035,380 | 2,257,710 |
| Asia and Oceania | 11,013,793 | 2,934,126 |
| Other countries | 1,114,487 | 202,083 |
| Total | 37,404,243 | 8,009,985 |

Though Great Britain makes the largest shipments the wool is not grown there, but comes mostly from Australia, with some contributions from South Africa and the Plata River region of South America.

The combing wools (class 2) are always a relatively small quantity, our various families (now recognized as breeds) of Merino Delaines producing a finer combing wool than the English breeds and furnishing much of the present supply. Class 2 includes the wool of these mutton breeds, and comes mostly from Great Britain, the home of the mutton sheep, though much of this may have been brought to London from the mother flocks of New Zealand and Argentina. Canada makes the next largest contribution to our imports of English combing wools. The following statement shows the sources of these foreign wools:

*Amounts and values of combing wools (class 2) imported in fiscal year ended June 30, 1900, by countries from which imported.*

| Countries. | Amount. | Value. |
|---|---|---|
| | *Pounds.* | |
| United Kingdom | 9,445,222 | $1,885,529 |
| Other Europe | 779,630 | 271,662 |
| British North America | 2,135,929 | 418,508 |
| South America | 206,472 | 48,600 |
| Asia and Oceania | 25,840 | 7,102 |
| Other countries | 38,190 | 7,325 |
| Total | 12,631,283 | 2,638,721 |

Class 3, miscellaneous wools, sometimes miscalled carpet wools, are the product of neglected flocks and unskilled breeding throughout the world. Some of these wools can be and have been used for coarse flannels, and some can be utilized in cheap cloths. As our carpet industry is flourishing, and so far held its own in the great depression of manufactures as to supply domestic consumption and keep out all but a few fancy weaves and special orders, most of this cheap stuff, costing less than an average of 10 cents per pound, and some of it not more than 7, necessarily goes chiefly into carpets. Indeed, in the manufacture of the best grades of carpets better wool is sometimes used. The wool of class 3 comes from the following countries:

*Amounts and values of wools of class 3 imported in fiscal year ended June 30, 1900, by countries from which imported.*

| Countries. | Amount. | Value. |
|---|---|---|
| | *Pounds.* | |
| United Kingdom | 29,349,316 | $3,199,216 |
| France | 3,784,008 | 375,298 |
| Germany | 2,187,716 | 233,117 |
| Other Europe | 21,660,166 | 1,988,625 |
| British North America | | |
| South America | 10,608,902 | 793,982 |
| China | 30,709,966 | 2,157,573 |
| Other Asia and Oceania | 7,138,676 | 823,896 |
| Other countries | 444,179 | 45,523 |
| Total | 105,882,929 | 9,617,230 |

The year ended June 30, 1900, has been one of remarkable activity in manufacture. The output has been unprecedented, yet the impor-

tations of wool in the three fiscal years, 1898–1900, have been less than one-half as much as the importations of the preceding three years. There has been wool used of previous importations because the glut had to be cleared away and the destruction of sheep had caused an insufficiency of the domestic product; yet there is reason to believe that in the presence of a full domestic supply of clothing and combing wools there would be no very urgent demand for the importation of any large quantity of wools except those of class 3.

It is indicative of the high standard of living in the United States that the consumption of wool in domestic and imported goods has increased in fifty years from 4 to 8 pounds per head.

While our importations of manufactures of wool have increased in each decade for fifty years, except the last, the value per capita of imports has been diminishing with much regularity for fifty years. For the ten years ended with 1860 this value per capita was the highest in the history of our foreign trade, $1.16; in the following decades, respectively, 94, 90, 74, and 46 cents. A heavy decrease is noted in the last decade, an effect, as the writer believes, of legislation tending to restrict importation and to stimulate domestic production. This is the more notable from the fact that the average annual imports of the free-wool period were nearly double those of the other seven years, being $47,065,760, although the prices were low and quantities of low-class goods correspondingly large. There were never so many goods before imported in three years, and they never were of so base a quality. Yet the reduction in value of imports since 1890, as compared with the previous decade, is 26 per cent, while our population has been increased about 20 per cent.

This affords a guaranty of our ability to produce all the woolens required for consumption. The machinery at present in operation is deemed sufficient, without much extra speeding or increase of running time, to supply the wants of a full rate of consumption.

*Value of net importations of manufactures of wool by decades, 1830–1900.*

| Ten years ended with— | Aggregate. | Annual average | Average value per capita. | Ten years ended with— | Aggregate. | Annual average. | Average value per capita. |
|---|---|---|---|---|---|---|---|
| 1830 | $82,900,615 | $8,290,062 | $0.75 | 1870 | $330,465,214 | $33,046,521 | $0.94 |
| 1840 | 139,507,716 | 13,950,772 | .94 | 1880 | 395,376,936 | 39,537,694 | .90 |
| 1850 | 130,058,518 | 13,005,852 | .65 | 1890 | 433,459,813 | 43,345,981 | .77 |
| 1860 | 313,332,730 | 31,333,273 | 1.16 | 1900 | 320,134,071 | 32,013,407 | .46 |

The magnitude of our woolen industry may not be appreciated fully. It has suffered from adverse legislation, but is now producing more than ever before. This is one of four great manufacturing countries, and every one of the four has built up its wool manufacturing industry by protective legislation. Great Britain alone has abandoned this policy. France stands at the head in importance of manufacture. Great Britain comes next, and Germany and the United States are

nearly equal. It will not be long, doubtless, in the absence of adverse legislation, before this country will surpass all others in the extent and value of manufactures of wool. It has one advantage possessed by none of its rivals—a domestic supply of two-thirds of the mill consumption and pastoral areas sufficient for the whole of it.

Other countries must depend mainly on foreign wool, as France, Great Britain, and Germany together only produce about as much as this country. This foreign dependence is thus indicated:

*Imports and exports of wool by France, Great Britain, and Germany for 1890 and 1899.*

| Countries. | Year. | Imports. | Exports. | Net imports. |
|---|---|---|---|---|
| | | *Pounds.* | *Pounds.* | *Pounds.* |
| France | 1890 | 371,722,377 | 39,575,579 | 332,146,798 |
| | 1899 | 558,456,820 | 64,993,961 | 493,461,859 |
| Great Britain | 1890 | 629,236,219 | 360,006,616 | 269,229,603 |
| | 1899 | 735,627,420 | 410,929,012 | 324,698,408 |
| Germany | 1890 | 283,542,424 | 19,872,264 | 263,670,160 |
| | 1899 | 391,636,633 | 19,920,064 | 371,716,569 |

France in 1890 had a domestic product of 124,803,000 pounds, which has greatly declined. Great Britain had 147,475,000 at that time, and Germany 54,894,000. The numbers of sheep in Germany and France have fallen off, increasing their dependence on imports of wool.

For the past ten years the wool supply of this country, domestic and foreign, has been about 430,000,000 pounds annually, which is about the same as that of Germany now, and nearly as large as that of Great Britain, exclusive of the stocks of shoddy and wastes of all kinds. About three-fourths of all the wool of the world is manufactured in these four countries, besides the remanufacture of the renovated rags of the world, of which the people of this country would be glad to accord Europe the monopoly, and with it the doubtful reputation of having the cheapest clothing.

The question has been repeatedly asked, Can we produce all the wools required for domestic manufacture? There is no doubt of the capacity of the country to produce more wool than is now consumed in any form. There are economic reasons that will doubtless prevent the production of very low-grade wools. Yet with 100,000,000 sheep there will be a considerable number of common sheep, such as Mexicans in the early stages of improvement; also the belly, neck, and breech wools of the coarse-wooled breeds will furnish a large quantity of carpet wool; and if these are not sufficient, woolgrowers will probably not object to the admission from abroad, at the present low rate of duty, of all that is necessary to meet the deficiency. But the clothing and worsted wools required can be and should be produced in sufficent quantity to meet the requirements of increasing population for many years to come. When our population is far more dense than at present, and the very limited exportation of woolen manufactures has

acquired a far greater volume, it will be time enough to begin to question the possibility of a full domestic wool supply.

The sheep is a factor in keeping up the fertility of lands. A million farms east of the Mississippi need them in their pastures to keep down growths of plants that cattle or horses do not touch. They are kept on lands in England far more valuable than the best in New York or Ohio.

Increasing population will require more meat. Years ago, when sheep were kept almost exclusively for wool, and the aged slaughtered for market in poor condition, tough and tasteless, "sheep meat" was not popular. Those days are past; mutton is appreciated and lamb is a delicacy that brings high prices. Mutton eating is rapidly increasing. It is taking the place of pork as a more palatable and healthful meat, and even reducing the relative consumption of beef, as in England.

It should be remembered that Ohio has had three times as many sheep as at present, and could easily care for 7,000,000 again; that the central West has had twice as many as now, with abundant lands for their pasturage, and for more than were ever before kept. Texas has kept three times as many as at the present time, and with increase of feeding resources, in forage plants, oil meal, and corn, in feeding supplementary to pasturage, can keep larger stocks than ever. The increase of beet-sugar factories, to be greatly accelerated in the future, furnishes material for feeding sheep in large quantities. Mutton production in the South, an industry feebly existent hitherto, can be made one of the most profitable in the agriculture of that section.

It is not easy to limit or measure the sheep-carrying capacity of the country, of the farms as well as the ranges. Little more than a third of the land is in farms, and, of many of the farms, not a third of the area is in cultivation or full occupation.

Maine, the "down-east" State of the Atlantic coast, has only a third of its area in farms, and its forest lands are among the most fertile in the East. The States east of the Mississippi can carry, without encroachment on other lines of rural industry, more sheep than there are now in the entire country.

Will this development be made? It depends entirely on economic conditions. If good prices of wool are maintained for a period sufficiently long to give the grower confidence, if practical education in feeding is advanced, and the promise of a permanently profitable business is assured, there is likely to be a realization of such an increase of flocks.

How many sheep would be required? Estimates have heretofore been considerably exaggerated. Sometimes it has been stated that 9 pounds per capita of wool are annually required in goods of all kinds. The consumption has never been so great. Eight pounds is

an ample estimate. The annual wool supply for the last ten years has averaged 444,514,274 pounds. The annual imports of manufactures of wool are valued at $32,013,407, against an annual average of $43,345,981 for the ten years ended with 1890. And these figures include, besides wool and manufactures of wool, a large proportion of shoddy and shoddy goods. Compare the fleece wools used in Great Britain with the quantity or value of manufactured goods, and an analysis will show how large a proportion of shoddy, flocks, mungo, and wastes of all kinds enter into the composition of this mass of manufacture. American shoddy itself makes an appreciable addition to the wools of the country, and always will, and they should be included in reckoning the wool requirements of our manufacture, appreciably reducing the amount required. In these high estimates of requirement every form of shoddy and waste, cotton and linen, that enters into the goods imported as woolens is counted as wool. It may be wool to the manufacturer, but it is not to the woolgrower.

A total of 60,000,000 sheep, producing 360,000,000 pounds of fleece and 60,000,000 pounds of butchers' wool, would have furnished very close to the supply for manufacture during the last ten years, without considering shoddy or substitutes. Should we reach a total of 80,000,000 sheep in a decade or two, a volume of 550,000,000 pounds of wool would be produced—more real wool than any nation in the world, except possibly France, has ever manufactured in a single year. When we reach 100,000,000, if we should, with 700,000,000 pounds of wool, fleece and pulled, with the substitutes that must be counted in manufacture, there would be a liberal and ample supply for a population of 100,000,000. This does not make allowance for a considerable quantity of carpet wools that are quite certain to be imported, and any other imports that manufacturers might fancy in their quest for novelties or preferences in wools, which must always reduce domestic requirements.

The present duties are not prohibitory. They will admit a large quantity of the third class, and more or less of the other two, no matter how large the domestic supply, but they will suffice to prevent an avalanche, maintain fair prices, and admit of gradual enlargement of wool production.

The fleece of the Angora goat, known as mohair, is one of the elements, however small, included with our foreign wool supply, and should be reckoned with the domestic. A few words regarding the Angora goat industry in this country are in order here. In 1849 Dr. Davis imported two bucks and six does of good quality. Colonel Peters followed with several importations. Diehl & Brown, in 1869, imported 135 animals; Mr. Israel Diehl had a commission from the Department of Agriculture to facilitate his work of selection. Maurice Brothers, of Texas, made importations in 1869, 1871, 1872, and 1873. Mr. John L. Harris went from California, in 1875, to Asia Minor to

investigate Angora breeding, and in California, Oregon, and Nevada has been engaged in breeding ever since, establishing large flocks and distributing to other States.

They are not confined to range districts, but have been held in many of the farming States from the Missouri to the seaboard. Recently there has been an active demand for them at advanced prices. In the agricultural exhibit of the Paris Commission there are 24 samples of mohair from a few of the prominent flocks, most of them collected by William R. Payne & Co., New York dealers in mohair and wools. They estimate the annual product of mohair at about 700,000 pounds, grown mostly in Texas, California, Oregon, and Nevada, and the number of goats at about 240,000.

### THE CLASSIFICATION AND HANDLING OF AMERICAN WOOLS.

Early in the spring of each year, at the shearing of the annual clip, the principal woolgrowing sections swarm with buyers representing woolen mills and dealers in wools. Many of these are residents of the country, buying on commission, sometimes on speculation on their own account. All the conditions and influences tending to lower prices are of course urged to depress values at this time; and if the tendencies are sharply toward a higher level, as in the spring of 1899, the buyers are careful not to give them publicity. Yet intelligent growers are alert to ascertain promptly and accurately the drift of prices. Others are sometimes caught napping and part with their wool at prices which leave too large a margin to the speculative middleman.

The merino wools, or clothing wools, are commonly classified as Picklock, XXX, XX, X, one-half blood, three-eighths blood, and one-fourth blood, according to quantity and fineness. Picklock is an extremely fine fiber, of which a very little is found in the remaining Saxony flocks of breeders in western Pennsylvania. Most of these breeders have modified their flocks to obtain heavier fleeces of longer fiber, bringing much more money. There is also very little of the XXX grade, which is only exceeded in fineness by the purest breeding of Saxony Merinos. The mass of high-grade clothing wool is of the XX and X grades. The lower grades are made by dealers according to fineness and quality, without a knowledge (which would be impossible to attain) of the precise fraction of Merino blood of the sheep producing them.

The combing wools are of two classes. Formerly they were exclusively of the English mutton breeds, or at least were not of Merino origin. The exigencies of wool manufacture, the insufficiency of supply of true combing wool, made it necessary to adapt machinery for combing the merino carding or felting wools. This rendered necessary a fiber longer than 2½ inches, which is about the length of the finer qualities. A considerable difference always existed in length of fiber

of different families under different climatic and nutritive conditions; it was easy, by selection and breeding, to increase the length, a process of modification which has been in progress for many years. This merino division of combing wools is classified in three grades—fine, the finest of long staple; medium, not quite so fine; and low, of combing length and a little finer than the combing wool of mutton breeds. These are classed as three-eighths blood, one-fourth blood, common, and braid, the last being the long and lustrous wools of the Lincolns, and also of Leicesters and Cotswolds.

The condition of wool is an important element of value and of profit in sheep husbandry. It is a matter that demands the attention of growers, who could readily obtain a few million dollars more for the annual clip, mostly additional profit, by greater care in management and better methods of handling.

Neglect of flocks in winter, insufficient supply of feed, the great difference between the succulent spring pasture and dry winter feed, perhaps scarcely more liberal than the run of straw stacks, will cause uneven quality, reduction of strength, and decrease in price. Lands allowed to be overrun with weeds will fill fleeces with seeds and burs, and what is saved in labor is doubly lost in lower price. A great deal of dust and chaff in fleeces can be obviated by a little attention to methods of feeding. Care in shearing is also important, resulting in saving of wool and in better condition of the fleece.

In the putting up of wool for market there has long been a cause of variance and friction between grower and buyer in all parts of the country. The buyer complains of filthy tags and dirt in the fleeces, and of the use of unnecessary quantities of unreasonably large twine of a quality that injures the fabric in the manufacture. On the other hand growers say that when they exercise the greatest care in all these respects the buyers will allow no discrimination in price. There is doubtless some truth in these countercharges, yet a lot of fleeces carefully handled, of even quality, would claim some consideration from a practical buyer, or they could be sent to a reliable commission house and command a price that would pay well for the extra care. There is evidently room for much improvement on the part of seller and buyer, and the subject is worthy of the thoughtful consideration of both.

The advisability of washing sheep before shearing has long been a subject for discussion. Its purpose is the better condition and higher price of the wool. The difficulty presented, which appears to be insuperable, is in obtaining a uniform condition of cleanness. Necessarily some flocks have more foreign matter in their fleeces than others; there is always great difference in the amount of yolk or grease which the ordinary washing does not affect. Facilities for washing are very poor on many farms and ranges, and different methods of washing are

very unequal in their results. If a grower is not inclined to be exactly square in his dealings, or if his perceptions of strict honesty are a little confused by the unfairness of buyers in making no discrimination as to degrees of cleanness in buying, he may slight the process or drive the flock through muddy water. As a rule the grower evidently intends to be honest, but in the warfare of trade, where Greek meets Greek in a contest for self-preservation, ethical views are apt to become confused. With all these obstacles, it seems to be impossible to assure any great degree of uniformity in the cleansing of fleeces by farm washing. Then it is desirable to shear early, to give the flock a better chance for comfort and growth in the warmth of later spring, and also to obtain an opportunity of choice of time in selling, prices often being better in the early spring; but very early shearing involves a risk of injury from exposure. Altogether, most flock raisers prefer not to wash, and nearly all dealers unite in a preference for unwashed wools. They find so much unevenness that, in buying washed wool, they usually make some deduction from established washed rates, and in some cases pay little more than for unwashed. It is said that much of the country washing is a positive disadvantage in scouring the wool. Therefore the practice of washing is declining; in many districts it has been almost abandoned. The practice is in vogue in Michigan only to a limited extent, 9,696,446 pounds being unwashed of 12,025,802 pounds purchased by dealers last year, as reported by Prof. Herbert W. Mumford, in Bulletin No. 178 of the Michigan State Agricultural College, a very thorough inquiry into the reasons why Michigan wools sell at a lower price than those of Ohio and Pennsylvania.

In some parts of the country where climatic causes interfere to prevent evenness of fiber, as in Texas, New Mexico, Arizona, and southern California, the practice of shearing twice annually is adopted, the winter fleece being stronger and of greater value than the brash fiber grown in summer. It is a saving of wool and a great saving in annual proceeds of flocks. The summer and winter growth do not work well together, reducing both qualities to a low level.

The use of sheep-shearing machines is increasing. They shear closer, secure more wool than hand shearing, leave the fleece in evener condition, and are not so liable to cut the skin of the sheep. Yet their use is confined mainly to large flocks beyond the Missouri River. Small flocks do not warrant the expense of these machines and the trouble of keeping their knives in order, which are returned to the factory to be sharpened.

Unquestionably it will be in the interest of the grower to reform the awkward and unseemly methods of tying up for market, avoiding unseemly packages, the use of heavy twine of unnecessary quantity, and the inclusion of tags and other rubbish. These defects are so easily seen and so repulsive in the sight of the buyer that they must

influence his offer. There is great objection to using hemp twine, which injures the fabric with which it is mixed, and anyone who has attempted to free a fleece of the interminable tangle of much of the elaborate tying in vogue will acknowledge the task a practical impossibility. A small linen twine is recommended, and as it costs nearly as much per pound as the wool, there is no inducement to use a large quantity, and little will be required, once around the fleece each way being ample for a light fleece, and twice for a heavy merino fleece.

Neatness and honesty in putting up all products for market are yearly becoming more important in wool, cotton, fruits, everything. In the long run they will materially increase the profit of the production. It will not pay to sacrifice the profit of production by awkward and distasteful packing. There are millions of dollars in this practical idea.

An avoidance of these knotty and troublesome causes of difference between seller and buyer may be secured by making general the scouring of wool. Now that prices are fixed as nearly as possible on a scoured basis, the advantage to the grower is all the greater. There are many of these scouring-mill plants, even as far west as New Mexico, and one heavy flock master says he saved $1,668 on his clip by scouring. The saving of the freight on the grease and dirt is alone a large item.

### THE COURSE OF PRICES.

The wool prices in the table following are for fine, medium, and coarse wools during a period of seventy years. They show frequent and sometimes sharp fluctuations, due to the influence of relative supply and demand, speculative operations in home and foreign markets, tariff changes, and other causes. Influences affecting prices are always operative, and analysis of their proportionate effect would require a volume. All that is deemed necessary here is to show what marked and more or less permanent changes in value have occurred.

One noticeable point is the cheapening of wool during the century. Near its beginning, in the period of war with Great Britain, the extreme quotation for the finest wool reached $2.50 per pound, but even then the lower grades were only a third as much. In 1824, when this record commences, the range of values by grades was from 68 to 40 cents, and higher values were reported in 1831, 1834, and 1837, with fluctuations down to 33 cents for fine in 1849. Later the requirements of the civil war period and the currency inflation made quotations higher, touching $1.02 for fine in 1865, when gold premiums were very high. In 1868, the time of sharp reaction in everything relating to wool, there was a fall to 48, and to 47 in 1871. When the flurry was over, in 1872, fine wool was up to 70 cents again. Then followed a long period of growth in the industries of woolgrowing and manufacture in this and all other woolgrowing countries. A gradual decline in the price of fine wool followed year by year, till

the price of 34 cents was reached in that ever-to-be-remembered year of culminating depression in prices, 1879, reacting to 50 cents in the following year, to decline gradually to 29 cents in 1893.

But this decline in fine wool does not give an accurate view of the fall in wool prices in the course of seventy years. While more than half was taken from the value of fine wool, medium fell from 53 to 33 cents, and coarse only from 40 to 29. It will be observed that these two grades in the beginning were 68 and 40, at the end 29 and 29. Fashion in fabrics ran to coarse weaves, to worsteds rather than to smooth cloths.

A reference to the table will show in several instances very marked fluctuations in price between January and July of the same year, as in 1824, fine falling from 68 to 55, and in 1831 rising from 70 to 75, and in 1836 again from 65 to 70 cents. In coarse wool in 1893, between January and July, there was a fall from 29 to 25, as in a similiar period in 1824 it fell from 40 to 30 cents, and in 1827 from 28 to 25 cents. At several dates in seventy years did coarse wool touch 25 cents, and in 1849 a lower figure, 23 cents. It can not be said that the record of prices of coarse wool has been marked by any serious or permanent decline.

*Wool prices of seventy years, 1824–1893.*

[Mauger & Avery's annual wool circular.]

| Year. | January. | | | July. | | | Year. | January. | | | July. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fine. | Medium. | Coarse. | Fine. | Medium. | Coarse. | | Fine. | Medium. | Coarse. | Fine. | Medium. | Coarse. |
| | *Cts.* | *Cts.* | *Cts.* | *Cts.* | *Cts.* | *Cts.* | | *Cts.* | *Cts.* | *Cts.* | *Cts.* | *Cts.* | *Cts.* |
| 1824 | 68 | 53 | 40 | 55 | 40 | 30 | 1859 | 60 | 52 | 45 | 56 | 40 | 35 |
| 1825 | 60 | 43 | 32 | 50 | 41 | 32 | 1860 | 60 | 50 | 42 | 55 | 50 | 40 |
| 1826 | 55 | 43 | 38 | 37 | 30 | 26 | 1861 | 45 | 40 | 37 | 38 | 30 | 22 |
| 1827 | 36 | 32 | 28 | 37 | 31 | 25 | 1862 | 48 | 50 | 50 | 48 | 47 | 45 |
| 1828 | 42 | 30 | 25 | 48 | 38 | 33 | 1863 | 75 | 68 | 70 | 75 | 70 | 65 |
| 1829 | 54 | 45 | 35 | 46 | 36 | 32 | 1864 | 80 | 78 | 76 | 1.00 | 1.00 | 90 |
| 1830 | 40 | 35 | 30 | 60 | 50 | 40 | 1865 | 1.02 | 1.00 | 96 | 75 | 73 | 65 |
| 1831 | 70 | 60 | 48 | 75 | 65 | 50 | 1866 | 70 | 65 | 50 | 70 | 67 | 60 |
| 1832 | 65 | 55 | 44 | 50 | 42 | 30 | 1867 | 68 | 53 | 50 | 55 | 49 | 45 |
| 1833 | 55 | 41 | 33 | 61 | 54 | 40 | 1868 | 48 | 43 | 38 | 46 | 45 | 43 |
| 1834 | 70 | 60 | 48 | 60 | 50 | 40 | 1869 | 50 | 50 | 48 | 48 | 48 | 47 |
| 1835 | 63 | 50 | 40 | 63 | 56 | 42 | 1870 | 48 | 46 | 44 | 46 | 45 | 43 |
| 1836 | 65 | 60 | 45 | 70 | 60 | 50 | 1871 | 47 | 46 | 43 | 62 | 60 | 55 |
| 1837 | 72 | 63 | 48 | 52 | 52 | 36 | 1872 | 70 | 72 | 66 | 72 | 70 | 65 |
| 1838 | 50 | 42 | 35 | 46 | 36 | 30 | 1873 | 70 | 68 | 65 | 50 | 48 | 44 |
| 1839 | 56 | 48 | 38 | 57 | 48 | 40 | 1874 | 58 | 54 | 47 | 53 | 53 | 46 |
| 1840 | 50 | 45 | 38 | 45 | 39 | 33 | 1875 | 55 | 56 | 47 | 52 | 49 | 46 |
| 1841 | 52 | 45 | 35 | 50 | 44 | 34 | 1876 | 48 | 52 | 42 | 38 | 35 | 31 |
| 1842 | 48 | 42 | 35 | 43 | 37 | 30 | 1877 | 46 | 43 | 36 | 50 | 44 | 37 |
| 1843 | 35 | 30 | 25 | 35 | 30 | 26 | 1878 | 44 | 45 | 38 | 36 | 36 | 32 |
| 1844 | 37 | 30 | 26 | 45 | 37 | 32 | 1879 | 34 | 35 | 32 | 37 | 38 | 34 |
| 1845 | 47 | 40 | 31 | 40 | 36 | 30 | 1880 | 50 | 56 | 48 | 46 | 48 | 42 |
| 1846 | 40 | 35 | 30 | 38 | 32 | 27 | 1881 | 47 | 49 | 43 | 42 | 44 | 36 |
| 1847 | 45 | 40 | 30 | 46 | 40 | 31 | 1882 | 44 | 46 | 47 | 42 | 45 | 34 |
| 1848 | 45 | 38 | 30 | 38 | 32 | 28 | 1883 | 40 | 43 | 33 | 39 | 41 | 33 |
| 1849 | 33 | 30 | 23 | 40 | 35 | 28 | 1884 | 40 | 40 | 34 | 35 | 34 | 30 |
| 1850 | 47 | 40 | 33 | 45 | 37 | 30 | 1885 | 34 | 33 | 29 | 32 | 31 | 28 |
| 1851 | 46 | 40 | 33 | 47 | 42 | 37 | 1886 | 35 | 36 | 32 | 33 | 33 | 29 |
| 1852 | 43 | 38 | 34 | 45 | 38 | 33 | 1887 | 33 | 38 | 34 | 34 | 37 | 34 |
| 1853 | 58 | 56 | 50 | 60 | 53 | 48 | 1888 | 31 | 35 | 33 | 29 | 33 | 31 |
| 1854 | 53 | 47 | 42 | 45 | 37 | 30 | 1889 | 34 | 38 | 33 | 35 | 39 | 32 |
| 1855 | 40 | 35 | 32 | 50 | 40 | 33 | 1890 | 33 | 37 | 29 | 33 | 37 | 29 |
| 1856 | 50 | 38 | 35 | 55 | 42 | 36 | 1891 | 33 | 37 | 31 | 31 | 35 | 29 |
| 1857 | 58 | 50 | 42 | 56 | 50 | 40 | 1892 | 30 | 35 | 31 | 28 | 34 | 30 |
| 1858 | 40 | 33 | 27 | 43 | 37 | 30 | 1893 | 29 | 33 | 29 | 24 | 26 | 25 |

*Philadelphia wool prices, 1885–1892.*

[Circular of Coates Brothers.]

| Kinds of Wool. | 1885. | 1886. | 1887. | 1888. | 1889. | 1890. | 1891. | 1892. |
|---|---|---|---|---|---|---|---|---|
| OHIO, PENNSYLVANIA, AND WEST VIRGINIA WASHED. | | | | | | | | |
| | Cents. | Cents. | Cents. | Cents. | Cents. | Cents. | Cents. | Cents. |
| XX and above | 32–35 | 34–35 | 34–36 | 29–31 | 34–37 | 33–35 | 31–33 | 28–30 |
| X | 30–31 | 31–33 | 32–34 | 28–29 | 33–34 | 31–33 | 29–31 | 27–28 |
| Medium | 30–31 | 34–35 | 38–40 | 32–35 | 38–40 | 37–39 | 36–37 | 33–35 |
| Quarter blood | 28–29 | 33–34 | 38–39 | 31–34 | 37–38 | 36–37 | 34–35 | 33–34 |
| Common and cotted | 22–25 | 27–30 | 30–35 | 28–30 | 30–33 | 28–30 | 28–31 | 28–31 |
| NEW YORK, MICHIGAN, AND INDIANA WASHED. | | | | | | | | |
| XX | 28–29 | 31–33 | 31–33 | 27–29 | 32–34 | 30–32 | 29–30 | 27–28 |
| X | 27–28 | 30–31 | 30–32 | 25–27 | 31–32 | 29–30 | 27–29 | 25–27 |
| Medium | 30–30 | 33–35 | 37–40 | 31–34 | 37–39 | 36–38 | 35–36 | 33–34 |
| Quarter blood | 27–28 | 32–33 | 37–39 | 30–33 | 36–37 | 35–36 | 33–35 | 32–33 |
| Common and cotted | 22–23 | 27–29 | 30–35 | 28–30 | 30–33 | 28–30 | 28–30 | 28–30 |
| COMBING AND DELAINE FLEECE. | | | | | | | | |
| Washed fine delaine | 33–35 | 33–35 | 36–38 | 31–33 | 36–38 | 35–37 | 34–36 | 31–33 |
| Washed medium | 32–35 | 35–36 | 38–40 | 34–36 | 38–41 | 38–41 | 38–39 | 35–37 |
| Washed low | 30–31 | 34–36 | 37–39 | 32–35 | 37–38 | 36–38 | 35–37 | 34–35 |
| Washed coarse | 27–29 | 32–34 | 35–37 | 30–33 | 33–36 | 32–33 | 32–35 | 30–33 |
| Unwashed, medium | 24–26 | 27–28 | 32–35 | 25–28 | 30–33 | 30–32 | 30–31 | 26–28 |
| Unwashed, low and coarse | 21–24 | 25–27 | 30–32 | 23–25 | 27–29 | 25–27 | 25–27 | 26–27 |
| LIGHT AND BRIGHT, UNWASHED. | | | | | | | | |
| Fine | 20–21 | 21–22 | 22–25 | 17–20 | 23–25 | 20–23 | 19–21 | 18–20 |
| Medium | 22–24 | 27–28 | 30–34 | 24–27 | 29–32 | 27–30 | 26–29 | 25–27 |
| Low medium | 20–22 | 25–26 | 28–30 | 23–25 | 28–29 | 25–27 | 24–26 | 24–26 |
| Coarse | 15–17 | 20–22 | 22–25 | 20–23 | 22–25 | 20–23 | 18–22 | 18–22 |
| DARK COLORED, UNWASHED. | | | | | | | | |
| Light fine | 17–20 | 19–21 | 19–22 | 15–17 | 20–22 | 17–20 | 16–18 | 16–18 |
| Heavy fine | ..... | ..... | 19–22 | 12–14 | 16–19 | 14–16 | 14–16 | 14–15 |
| Medium | 18–20 | 22–25 | 25–28 | 16–20 | 23–26 | 22–24 | 20–22 | 19–22 |
| Fine medium | 16–18 | 22–23 | ..... | 15–17 | 20–23 | 18–22 | 17–19 | 16–18 |
| Coarse | 15–16 | 17–19 | 22–24 | 15–16 | 18–22 | 16–18 | 18–20 | 17–20 |
| COLORADO, UNWASHED. | | | | | | | | |
| Medium and fine, choice | 17–20 | 23–26 | 25–28 | 20–23 | 24–27 | 22–25 | 22–24 | 21–23 |
| Medium and fine, heavy | 17–18 | 21–23 | 22–24 | 18–20 | 18–22 | 16–20 | 15–18 | 15–17 |
| Common and quarter blood | 16–17 | 20–21 | 20–22 | 16–18 | 19–22 | 18–20 | 18–20 | 17–19 |
| Coarse, carpet | 15–16 | 17–18 | 17–18 | 14–16 | 17–18 | 16–17 | 16–17 | 16–17 |
| NEW MEXICAN, UNWASHED. | | | | | | | | |
| Choice improved | 16–20 | 22–25 | 23–26 | 19–22 | 24–26 | 22–24 | 20–22 | 21–22 |
| Partly improved | 15–16 | 19–21 | 21–23 | 16–18 | 21–23 | 19–21 | 18–20 | 17–19 |
| Coarse, carpet, light | 14–15 | 17–18 | 16–18 | 14–16 | 17–18 | 16–17 | 16–17 | 15–16 |
| Coarse, carpet, heavy | 13–14 | 15–17 | 15–16 | 13–14 | 15–17 | 14–16 | 14–16 | 13–15 |
| Black | 12–13 | 15–16 | 15–16 | 12–15 | 16–18 | 15–17 | 14–16 | 12–15 |
| TEXAS, UNWASHED. | | | | | | | | |
| Fine, 12 months | 18–22 | 21–24 | 20–23 | 16–18 | 20–24 | 20–22 | 20–22 | 18–20 |
| Medium, 12 months | 20–25 | 25–27 | 25–28 | 18–24 | 24–28 | 24–26 | 23–24 | 20–24 |
| Coarse, 12 months | 14–15 | 17–18 | 18–20 | 14–15 | 18–22 | 18–20 | 17–19 | 17–19 |
| MONTANA, UNWASHED. | | | | | | | | |
| Fine bright | 20–22 | 20–23 | 21–23 | 16–18 | 20–24 | 20–22 | 17–21 | 17–20 |
| Medium bright | 20–22 | 24–27 | 26–28 | 18–22 | 24–28 | 24–26 | 21–24 | 20–24 |
| Coarse bright | 16–18 | 20–23 | 20–23 | 16–18 | 20–22 | 18–20 | 18–20 | 17–20 |
| Dark colored, heavy | 16–18 | 18–20 | 18–20 | 14–16 | 17–22 | 16–20 | 16–20 | 15–18 |
| UTAH AND WYOMING, UNWASHED. | | | | | | | | |
| Light fine | 18–19 | 20–22 | 20–23 | 14–16 | 19–22 | 18–20 | 17–20 | 17–20 |
| Heavy fine | 16–17 | 18–20 | 18–20 | 12–14 | 16–19 | 14–16 | 14–16 | 14–16 |
| Fine medium | 17–18 | 21–23 | 22–24 | 15–17 | 20–24 | 18–21 | 18–21 | 18–20 |
| Selected medium | 19–20 | 24–26 | 26–28 | 18–22 | 24–27 | 21–24 | 22–24 | 22–24 |
| Low | 15–16 | 17–19 | 22–24 | 16–18 | 20–22 | 19–21 | 18–21 | 18–20 |

*Philadelphia wool prices, 1885–1892*—Continued.

[Circular of Coates Brothers.]

| Kinds of wool. | 1893. | 1894. | 1895. | 1896. | 1897. | 1898. | 1899. | 1900. |
|---|---|---|---|---|---|---|---|---|
| OHIO, PENNSYLVANIA, AND WEST VIRGINIA, WASHED. | | | | | | | | |
| | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Cents.* |
| XX and above | 25–26 | 20–21 | 17–19 | 17–19 | 21–23 | 28–30 | 28–30 | 28–30 |
| X | 24–25 | 18–20 | 16–17 | 16–17 | 20–21 | 26–28 | 26–28 | 27–28 |
| Medium | 27–28 | 20–22 | 19–20 | 18–19 | 22–23 | 28–30 | 29–30 | 30–32 |
| Quarter blood | 26–27 | 20–23 | 21–22 | 18–19 | 22–23 | 28–30 | 28–30 | 30–32 |
| Common | 24–25 | 18–19 | 18–19 | 17–18 | 20–22 | 24–25 | 25–27 | 27–28 |
| NEW YORK, MICHIGAN, AND INDIANA, WASHED. | | | | | | | | |
| XX | 23–25 | 18–20 | 16–17 | 16–17 | 19–20 | 25–26 | 23–25 | 24–25 |
| X | 22–23 | 16–18 | 15–16 | 15–16 | 18–19 | 23–25 | 22–23 | 23–24 |
| Medium | 27–27 | 20–21 | 18–20 | 17–19 | 21–22 | 27–29 | 28–30 | 30–31 |
| Quarter blood | 25–26 | 20–22 | 20–22 | 17–19 | 21–22 | 27–29 | 28–29 | 30–31 |
| Common | 24–25 | 18–19 | 17–18 | 16–18 | 20–21 | 23–25 | 25–26 | 27–28 |
| COMBING AND DELAINE FLEECE. | | | | | | | | |
| Washed fine delaine | 25–27 | 20–22 | 18–20 | 18–20 | 22–23 | 29–30 | 30–32 | 30–32 |
| Washed medium | 28–30 | 21–23 | 20–22 | 19–20 | 23–24 | 29–30 | 30–31 | 31–33 |
| Washed low | 27–28 | 22–23 | 22–23 | 19–20 | 23–24 | 28–30 | 29–30 | 31–33 |
| Washed coarse | 25–26 | 20–21 | 19–20 | 18–19 | 22–23 | 25–27 | 26–28 | 28–30 |
| Unwashed medium | 21–23 | 17–18 | 16–18 | 15–16 | 18–19 | 22–23 | 23–24 | 24–25 |
| Unwashed quarter blood | 20–21 | 17–19 | 17–19 | 15–16 | 19–20 | 22–23 | 22–24 | 24–25 |
| Unwashed braid | 18–20 | 16–17 | 16–17 | 14–15 | 18–19 | 20–21 | 20–21 | 20–21 |
| LIGHT AND BRIGHT, UNWASHED. | | | | | | | | |
| Fine | 15–18 | 10–13 | 11–13 | 10–12 | 13–15 | 18–20 | 17–20 | 17–19 |
| Medium | 20–22 | 14–16 | 15–17 | 14–15 | 17–18 | 21–23 | 22–23 | 23–24 |
| Quarter blood | 19–20 | 15–17 | 16–18 | 14–15 | 18–19 | 21–22 | 21–23 | 23–24 |
| Coarse | 17–18 | 14–16 | 15–16 | 13–14 | 17–18 | 19–20 | 19–20 | 17–20 |
| DARK COLORED, UNWASHED. | | | | | | | | |
| Light fine | 13–15 | 8–10 | 9–10 | 8–10 | 11–12 | 14–15 | 14–16 | 15–17 |
| Heavy fine | 11–12 | 6– 8 | 6– 8 | 6– 8 | 10–11 | 12–13 | 12–15 | ..... |
| Medium | 16–18 | 11–13 | 12–13 | 11–13 | 13–15 | 17–18 | 17–19 | 20–22 |
| Fine medium | 14–16 | 10–12 | 10–12 | 10–12 | 13–14 | 14–16 | 15–17 | 16–20 |
| Coarse | 14–17 | 11–12 | 11–12 | 11–13 | 13–15 | 14–15 | 15–16 | 16–18 |
| COLORADO, UNWASHED. | | | | | | | | |
| Medium and fine, choice | 16–19 | 11–13 | 11–13 | 11–13 | 12–15 | 15–16 | 16–17 | 16–20 |
| Medium and fine, heavy | 12–14 | 7–10 | 8–10 | 8–10 | 9–11 | 12–13 | 12–13 | 12–14 |
| Common | 14–16 | 12–13 | 10–12 | 10–12 | 12–15 | 14–15 | 13–15 | 15–16 |
| Coarse, carpet | 13–14 | 11–12 | 10–11 | 10–11 | 10–13 | 12–13 | 12–13 | 14–15 |
| NEW MEXICAN, UNWASHED. | | | | | | | | |
| Choice improved, light | 15–18 | 12–13 | 12–13 | 11–13 | 13–15 | 15–16 | 16–17 | 16–19 |
| Partly improved, light | 14–15 | 11–12 | 11–12 | 10–12 | 12–14 | 14–16 | 14–15 | 15–17 |
| Coarse, carpet, light | 12–13 | 10–12 | 9–10 | 10–11 | 11–13 | 12–13 | 12–13 | 14–15 |
| Coarse, carpet, heavy | 11–12 | 8–10 | 8– 9 | 7– 9 | 9–11 | 10–12 | 10–12 | 12–14 |
| Black | 10–12 | 9–10 | 8–10 | 7– 9 | 10–12 | 12–13 | 12–13 | 13–15 |
| TEXAS, UNWASHED. | | | | | | | | |
| Fine, 12 months | 15–17 | 10–12 | 10–12 | 9–11 | 11–13 | 12–13 | 13–15 | 15–17 |
| Medium, 12 months | 17–20 | 11–13 | 12–14 | 11–12 | 13–15 | 14–15 | 15–17 | 15–20 |
| Coarse, 12 months | 13–15 | 10–11 | 10–12 | 10–11 | 11–13 | 13–14 | 14–15 | 14–16 |
| MONTANA AND DAKOTA, UNWASHED. | | | | | | | | |
| Fine bright | 14–16 | 8–10 | 9–11 | 8–10 | 11–13 | 12–13 | 12–14 | 16–18 |
| Medium bright | 17–20 | 10–12 | 11–14 | 10–12 | 13–15 | 15–16 | 17–18 | 18–20 |
| Coarse bright | 15–17 | 10–12 | 11–13 | 9–10 | 12–14 | 14–15 | 15–16 | 16–18 |
| Dark colored, heavy | 12–14 | 6– 8 | 8–10 | 6– 8 | 9–11 | 11–13 | 11–13 | 14–16 |
| UTAH AND WYOMING, UNWASHED. | | | | | | | | |
| Light fine | 12–14 | 7– 9 | 9–10 | 8–10 | 11–12 | 12–13 | 14–15 | 16–17 |
| Heavy fine | 10–12 | 6– 8 | 8– 9 | 6– 8 | 9–10 | 10–11 | 12–13 | 14–15 |
| Fine medium | 14–15 | 8–10 | 10–12 | 9–11 | 12–14 | 14–15 | 15–17 | 17–20 |
| Selected medium | 16–18 | 10–12 | 12–14 | 11–13 | 13–15 | 16–17 | 17–18 | 20–21 |
| Low | 14–16 | 10–12 | 10–12 | 9–10 | 12–13 | 13–14 | 14–15 | 16–18 |

The decline in the wholesale price of Texas medium from 24–26 in 1890 to 11–12 in 1896 was a discouraging fall, but the drop in farm prices of this highest quality of Texas wool from 23 to 9 cents was ruinous. The farm prices of the lowest grades, not given in this table, were scarcely half as much.

The Montana wools, at the lowest point, are quoted in the lower grades at 6–8 cents, and the new Mexican at 7–9. These figures meant 4 to 5 cents to the growers.

In these quotations Ohio medium is recorded at 38–40 cents in 1887 and 1889, with somewhat lower prices in other years, feeling the competition with Australian skirted wools after 1890, and quoted in 1892 at 33–35. Then, owing, doubtless, to the expectation of free wool, the price fell to 27–28 in 1893, 20–22 in 1894, 19–20 in 1895, and 18–19 in 1896. In 1897 it rose to 22–23, in 1898 to 28–30, in 1899 to 29–30, reaching the highest point of recovery in January, 1900—35–38 cents. It required three years to clear away the accumulation of foreign wool.

Prices recently have been temporarily depressed by the slow sales and low prices in London, in consequence of accumulations of stocks drawn from all parts of the world by the high prices of last autumn and winter. There is great activity in manufacture in all manufacturing countries, and while the production of wool is increasing, there is an admitted scarcity of fine wools, which must tell favorably on future prices.

### PERIODS OF DECLINE AND REVIVAL.

Sheep husbandry is an industry peculiarly sensitive to influences either adverse or favorable. Early in the present century, when importations of the Spanish Merino elicited general interest, and in the period of the war of 1812, when clothing supplies were dependent on domestic manufactures, speculation was rife and prices were high, record being made up to $1,000 for a single individual for breeding purposes. Woolgrowing became a craze in New York, Massachusetts, and Vermont, and excited much attention in other States as far south as Maryland and Virginia.

The manufactures of those days were mostly domestic or household products. England furnished nearly all of the supplies that were not homespun. At the beginning of the war of 1812 duties were necessarily raised. The effect was a prompt and potent stimulus to home manufactures. But in 1816, after the war, duties were reduced without foreseeing the disastrous results which followed. The market was soon overburdened with foreign goods, prices fell heavily, and the manufacture of wool nearly ceased. It was at this time that Lord Brougham is reported as saying that "it is well worth while to incur a loss upon the first importations, in order by the glut to stifle in the

cradle those rising manufactures in the United States which the war has forced into existence contrary to the natural course of things."

For eight years there was little progress in manufacture and small encouragement to woolgrowing. Sheep were few and neglected. Business was paralyzed, distress general and severe. Under the tariff of 1816 not only was wool manufacture stranded, but earthenware making disappeared, glass factories were blown out, and iron manufacture diminished yearly. Losses greater than those of the war were impoverishing the country. Henry Clay referred to this period as the time of the most widespread dismay and desolation since the adoption of the Constitution.

After the tariff of 1824 woolgrowing and its manufacture revived, sheep increased, and in 1830 a promising start had been made and the value of manufactured goods was $14,528,166. During this decade only 8,000,000 pounds of foreign, added to the domestic, wool was manufactured annually. The wool manufacture continued to increase until 1833, the woolgrowers prospered, and the gloom and distress of the former period were followed by industrial activity and great prosperity.

Then came another period of discouragement to woolgrowers. The compromise act of 1833 provided for a gradual reduction of duties till 1842, to be succeeded by a uniform duty of 20 per cent. In four years of decline, intensified each year, wool manufacture was again prostrated, and with it the industries of the country, in a financial panic the severest in some respects ever known in the history of the country.

When 1842 came in, instead of the proposed moderate revenue duty, a protective enactment insured a new era of prosperity to both branches of the wool interest, to be again prostrated by a reduction in 1846, which caused the closing of many factories within the next two years and further discouragement to woolgrowing. In the years following, a period of stirring events, the finding of gold in California, the great development of gold and silver mining, the Crimean war, the growing demand for cotton throughout the world, were boom elements, causing activity and growth in many lines; yet wool manufacture languished, growing feebly with the demands of a rapidly increasing population, till the enactment of the Morrill tariff in 1861 and the era of enormous war demand, which in four years doubled the manufacture, increasing the wool consumption in factories from 80,000,000 to 160,000,000 pounds. Partial mill returns in 1864 made a total of 120,000,000 pounds, and further investigation gave a reasonable assurance of 40,000,000 more. For the four years there is a statistical showing of the Department of Agriculture of an average wool supply of 145,000,000 pounds per annum.

In eight years the number of sheep was almost and the amount of

wool fully doubled. This showed the marvelous possibilities of American woolgrowing under favorable circumstances.

It was a very remarkable exhibit of these possibilities that under the unusual exigencies of that period creating an extraordinary demand for woolens, which was greatly increased by the wastes of war, these demands were met by home manufacture with a smaller importation per capita than in the preceding decade of low prices and universal peace. Wool imports increased from 31,638,000 pounds in 1861 to 67,917,031 in 1865. The average price advanced from 13.7 cents in the former year to 17.6 in 1865, but fell in 1867 to 13.8, causing a marked increase in quantity imported. Flocks were enlarged as rapidly as possible, but the increase in wool was relatively larger than in sheep, resulting from the use of heavy wooled Merino sires in the flocks of Texas, New Mexico, California, and the Rocky Mountain range country.

In the war period new branches of textile fabrication were introduced or greatly extended, including the manufacture of fine worsted goods for ladies, new styles of fancy cassimeres, carpets, and other textiles, and the prices of some were actually cheapened by the home competition with what had been a foreign monopoly. Greater progress was made in respect to quality and variety of goods than for twenty years prior to 1860.

This period was one of remarkable development of woolgrowing and wool manufacture throughout the world. It was not alone the demand for goods caused by the civil war in this country, but the arrest of cotton growing and the blockade which hindered the shipment of the little that was grown, which caused a dearth of cotton, that alarmed the commercial world and stimulated the production of woolen goods to take the place of cotton. The increase in the average price of wool imports, 28 per cent in five years, indicates the sudden enlargement of woolen manufacture throughout the world. The exports of British manufactures of wool increased in these five years from £14,444,774 to £25,251,889, a total greater than that of the exports twenty years later. The wool imports of Great Britain nearly doubled in the same time. The industry in France, Germany, and other countries was similarly stimulated, and prices of the raw material and of the goods were similarly advanced.

After the close of the war, as cotton growing began to assume importance again, the boom in wool showed signs of decline. The wool supply, which had been so greatly enlarged in Australia, South Africa, South America, and North America, and even in Europe, was now in excess of the demand, and in 1865 the average price of our wool imports was reduced to the level of 1861. Abroad prices were falling in the expectation that cotton growing would promptly occupy its former position; in this country they were further reduced by the

decline of the gold premium. Our woolgrowers, who had been elated by the unaccustomed prosperity of the recent past, began to succumb to despondency, which affected first the flock owners east of the Missouri, inducing migration to the great ranges and a free movement to city markets. This discouragement gradually deepened until 1868, when panic seized the woolgrowers, and the slaughter of the flocks, especially the culls and lower grades, for the pelts and tallow, commenced in the great woolgrowing centers at improvised slaughtering and rendering establishments, which paid 75 cents to $1.50 each. The "hams" of the best were saved and salted for use as mutton. This destruction was more general in Ohio than elsewhere. In the principal woolgrowing counties the reductions were from 10,000 to 40,000; in Michigan and other States slaughtering was also active. The assessors' returns in Ohio in 1868 showed a reduction of 1,349,855, and in the two following years a loss of 1,969,736 more. The total decrease in Ohio in three years, from 7,622,495 to 4,309,904, was 43 per cent. The total reduction in the United States in 1868 was 4,500,000, according to published estimates of the Department of Agriculture.

The Department's review of the condition of farm animals in April, 1869, reflected the demoralization which had befallen the industry. It shows the great injury from neglect and disease which invariably results from discouragement at such a time of panic, as follows: "The wool business has been comparatively unprofitable of late, and the inevitable result is neglect, short commons, a supply of moldy hay, and the roughest treatment, in too many instances resulting in leanness, weakness, and insidious approaches of disease. Where they have been suitably cared for they are healthy, and as Merinos are in present disfavor, disease is mainly among flocks of that breed. Were it not for the cutting process by which millions of the poorest have been remorselessly slaughtered for their pelts and the small modicum of fat that could be drained by hydraulic pressure from their juiceless carcasses, the ravages of disease would have proved far greater."

One of the "last straws" that burdened the markets and helped to break them down was the sale by Q. M. Gen. M. C. Meigs, in the fiscal years 1866 to 1871, inclusive, of an immense surplus of military clothing. It included 2,218,917 overcoats, 802,419 blankets, 353,887 pantaloons, 359,253 sack coats, 427,729 jackets, 639,569 felt and other hats, 404,006 flannel and other shirts, 104,903 yards flannel, 152,951 yards kersey, 60,791 yards dark blue cloth, 216,380 pairs stockings, and other clothing material. There were overcoats alone enough to supply a third of all the voters in the country. This, in addition to the glut of commercial stocks of woolens, could not fail to produce a very disastrous result.

The estimates of sheep and wool, as stated approximately in round numbers in response to a resolution of the United States Senate, for

ten years commencing with the first enumeration after the commencement of the war, with the fleece wool, not including the pulled wool from sheep slaughtered which was considerable in the later years of this period, are as follows:

*Estimated number of sheep and product of wool in the United States, 1862–1871.*

| Year. | Sheep. | Wool. | Year. | Sheep. | Wool. |
|---|---|---|---|---|---|
| | | *Pounds.* | | | *Pounds.* |
| 1862 | 24,000,000 | 67,000,000 | 1867 | 42,000,000 | 147,000,000 |
| 1863 | 28,000,000 | 82,000,000 | 1868 | 41,500,000 | 155,000,000 |
| 1864 | 31,000,000 | 95,000,000 | 1869 | 37,000,000 | 143,000,000 |
| 1865 | 35,000,000 | 115,000,000 | 1870 | 34,000,000 | 135,000,000 |
| 1866 | 38,000,000 | 135,000,000 | 1871 | 32,000,000 | 128,000,000 |

These figures cover the fluctuations of periods of prosperity and adversity in wool production which affected profoundly this industry in all parts of the world, and the causes had their origin mainly in conditions prevailing in this country.

### TARIFF CHANGES AND THEIR EFFECTS.

It was during this period of depression, before its culmination, that the tariff of 1867 was enacted. The question has been asked, why it did not avert the disaster. The fact is that it was too late. The mischief had been already done. As early as 1865 the imports of manufactured wools, more than double the requirements of demand, began to glut the markets. Prices were falling throughout the world. But that enactment opened a new era of prosperity for woolgrowing, after the glut of goods had been absorbed, in which flocks increased 60 per cent in thirteen years and the wool product 100 per cent—the number of sheep, 50,626,626 in 1884, being larger than at any other time in the history of American woolgrowing.

In 1883 there was a slight change in the tariff, and in years following revenue decisions liberal to importers, which tended to discouragement of woolgrowers and a decrease of flocks, reducing the numbers in five years about eight millions, from 50,626,626 to 42,579,079. Values were highest in 1883, before the tariff enactment, $2.57, and lowest in January, 1886, but not increasing materially until the enactment of the McKinley law. The decrease in numbers was 16 per cent, and in price 24 per cent. An expectation of tariff revision prevented further sacrifice of flocks.

A new era of prosperity commenced in 1890. In four years the number of sheep increased to 47,851,000, or 11 per cent, from 1889, and the farm value advanced in January, 1893, to $2.66, the highest value for eighteen years, since 1875.

In 1894 was enacted a law making wool absolutely free, as well as all forms of shoddy and waste materials used in adulteration. The

effect was instantaneous. Prices of wool and of sheep declined, resulting in destruction of flocks and indifference and neglect in their care.

The law of 1897 followed, restoring customs duties on wool. The effect of this act has been to restore confidence in the future of woolgrowing and a larger degree of prosperity, though the enormous accumulation of foreign wool has retarded manufacture and sale until quite recently. For two years the mill stocks and wool markets were weighted down with foreign wool. Estimates of the trade authorities made the supply in January, 1900, 250,000,000 pounds less than in the preceding January. Consumption has been unprecedented and manufacture extremely active.

The value of sheep is nearly doubled. The Department estimate of average value in January, 1895, was $1.58 per head, and last January, $2.93. The increase in the price of wool is strikingly indicated by a diagram (fig. 1) prepared by Justice, Bateman & Co., showing the London value of American wool, with American prices of the same grade, and London value of similar Australian wool, from 1892 to 1900, the depression of the free-trade period, and the subsequent recovery under present law.

It appears that XX Ohio, which was worth 18 cents in London in 1897, when the Dingley bill was passed, rose to 23½ cents in the United States, though our markets were burdened with an enormous supply of foreign wool bought on a free-wool basis; and the next year, when a relief from this handicap had barely commenced, it was worth 29 cents here and 19½ cents in London. Since then there has been a great boom in foreign wool, which sent prices up temporarily, and in 1899 XX Ohio ran in London to 25½ cents and was 29½ cents here; but the collapse of the London boom has brought the price down to 22½, while it is here 31 cents, or 5 per cent above the average of last year. The London decline, both of XX Ohio and of scoured Botany Tops, is 12 per cent below the average of last year's prices.

The diagram shows in XX Ohio a comparatively slight fluctuation in London between 1892 and 1897, but in this country a fearful fall, 29½ to 17½ cents, where it remained with slight change for three fateful years, at the bottom of a depression which was a veritable slough of despond to the American woolgrower. The recovery under the present law, shown in a line almost vertical, is as sudden as the fall was precipitate.

The effect of the law of 1894 on manufacturers was scarcely less injurious than upon woolgrowers. They were not subjected to free goods, but were exposed to a competition under a reduced rate of duty, which they could not withstand, flooding the country, stopping sales, first exhausting profits, then reducing wages, and finally shutting down mills.

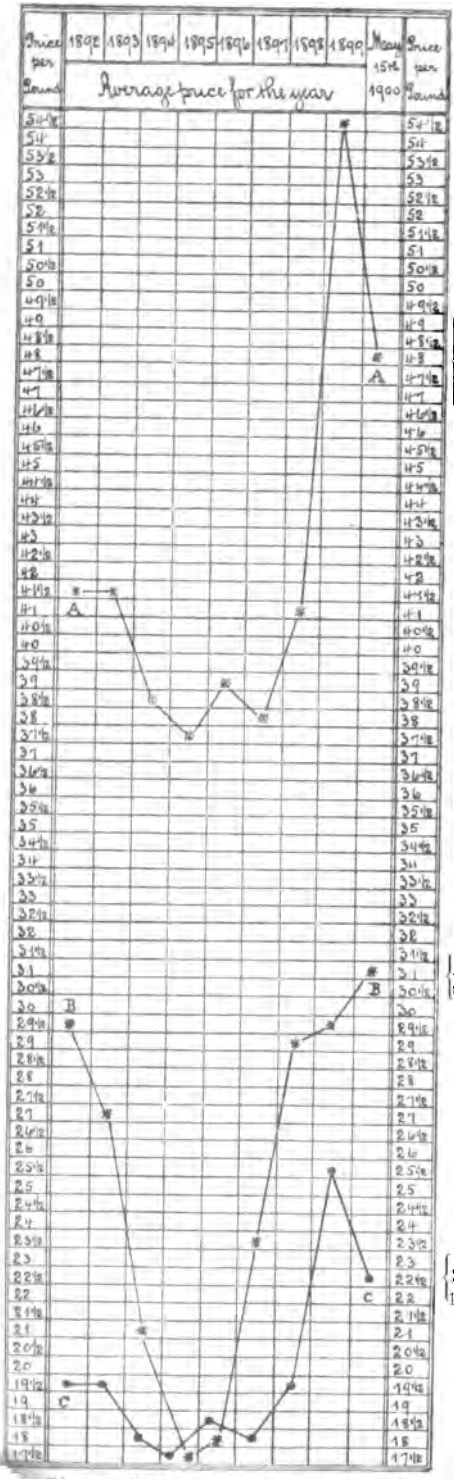


Diagram showing fluctuations in the price of wool, 1892-1900.

LINE A TO A represents London values of Merino wool scoured, carded, and combed into No. 60's Botany Tops, wool similar to XX Ohio. On May 15, 1900, the decline from the average of 1899 was 12 per cent.

LINE B TO B represents American prices for XX Ohio. On May 15, 1900, the advance from the average of 1899 was 5 per cent.

LINE C TO C represents London values of XX Ohio. On May 15 the price had fallen 12 per cent below the average of 1899.

Most of the manufacturers knew that free wool, under existing conditions, would prove inimical to their prosperity, though a few desired it. One of those, after a sad experience with the law of 1894, says:

> We as well as others thought this Wilson bill would be a godsend to all interested in the woolen line, but we have had the experience, and a good lesson it has been to us, and one that we are not likely to forget as long as we live.

Those who favored free wool and woolens have claimed that manufacturers, with the markets of the world in which to select their raw material, could make better goods, supply the country, export freely to other nations, and achieve a wonderful prosperity. Every one of these claims has been signally disproved by the experiences of 1894–1897.

It is no boast to say that there are no stronger or more serviceable wools in the world than those of the United States. They are wools of a temperate climate and of a progressive agriculture, and not from flocks of the torrid zones, neglected in breeding and care; they are from sheep bred toward the most approved types of clothing and combing wools. All the families of Merinos and all the improved English mutton breeds are represented. No European country has such a variety of wools as America, and none a superior average quality. Excepting Europe, the British colonies, and the Plata River region, all other countries grow wools distinctly and greatly inferior to ours. If we must depend on the wools of foreign countries we must be subject to competitive buying by England and other countries, under a serious handicap of trade and transportation advantages; must take what we can get; and a large portion must be the harsh and weak fiber of hot climates and that of neglected and poorly fed flocks—kempy, burry, and dirty. Is this a condition for securing better wool or better cloth?

Australian wools are popular, but their Merino blood came from Germany and America (Vermont and New York), and their Lincolnshire crosses furnish a lustrous article, very desirable for certain fabrics. The climate, with its torrid seasons of drought and destruction, is unfavorable for evenness and strength of fiber, and such wools are not equal in integrity and durability to our Merino.

While admitting the preference of fashion in certain fabrics, it is undeniable that the riddance of dirt and inferior portions of the fleece by skirting, and the smaller shrinkage resulting in part from this practice, gives most of the superior selling price of this wool in the markets. It is true that the manufacturer naturally likes unlimited range for selection, and truer still that price advantage—cheapness—is a factor of more controlling influence than any other in the selection and blending of material and fabric modification. Under the exigency

of scarcity and dearness, even a carding wool has been made a combing wool, requiring invention and adaptation of machinery to aid in the transposition, so that now a considerable portion of the worsted manufacture is from the Merino instead of the mutton breeds. In all the kaleidoscopic changes of style and admixture of material, it is by no means fashion that is the only or main consideration, but relative economy.

The law of 1894, instead of bettering the quality of the supply of woolens, degraded it to a condition never before existing, precipitating an era of shoddy. Mr. S. N. D. North, the secretary of the Wool Manufacturers' Association, testified before the Ways and Means Committee, in January, 1897:

> There has been more shoddy used in American goods in the year just passed than ever before, and more shoddy, mungo, and miscellaneous refuse contained in the goods imported in that year than have come into the United States in any previous twenty-five years.

And he said further, that nothing could be more certain, if conditions which introduced them should continue, than that the American manufacturer must meet them by the use of similar materials. He showed a piece of cloth, ingeniously fabricated to look like honest goods, in which there was not a particle of new wool, but which was made from the vilest of shoddy, and sold at a profit at less per yard than the market price of a pound of clean wool. In the testimony of one of the dealers in "woolen rags" it was admitted that some of this stuff was imported in a "condition decidedly offensive, and a great menace to the health of the community."

American shoddy from tailors' clippings and clean rags is a decent article compared with the lowest class of European material, known as mungo, which comes from cloth which may be first worn by a fastidious gentleman, who sells it to a secondhand dealer, to be next worn by a clerk or mechanic, then by a laborer, a tramp, or beggar, in its descent to the gutter, saturated with filth and germs of diseases and half rotten, thence to be resurrected, washed, treated with chemicals, and run through disintegrating machinery to appear as "mungo," selling at less than a cent per pound, and put into goods selling at a shilling per yard, and offered to American citizens as a boon to the poor man and a blessing to the clothing buyer of small means.

The figures of the United States Treasury record of imports are eloquent in portraying the inundation of foreign shoddy and shoddy goods, during the period covered by the law of 1894. The rags and various wastes imported under the two laws are thus compared:

*Amount and value of woolen rags, shoddy, mungo, etc., imported into the United States, 1892–1900, by three-year periods.*

| Year ended June 30— | Law of 1890. | | Law of 1894. | | Law of 1897. | |
|---|---|---|---|---|---|---|
| | Amount. | Value. | Amount. | Value. | Amount. | Value. |
| | *Pounds.* | | *Pounds.* | | *Pounds.* | |
| 1892 | 262,992 | $87,825 | | | | |
| 1893 | 333,376 | 106,596 | | | | |
| 1894 | 143,002 | 47,522 | | | | |
| 1895 | | | 14,066,054 | $1,980,464 | | |
| 1896 | | | 18,761,109 | 2,651,237 | | |
| 1897 | | | 49,413,642 | 6,935,658 | | |
| 1898 | | | | | 3,298,751 | $697,622 |
| 1899 | | | | | 314,540 | 70,224 |
| 1900 | | | | | 435,854 | 86,887 |
| Average | 246,456 | 80,647 | 27,550,268 | 3,855,786 | 1,349,715 | 284,911 |

The law of 1894 went into effect August 1 of that year, so there were only eleven months of imports of the fiscal year ended June 30, 1895; and as the law of 1897 went into effect as to shoddy January 1, 1898, the record of 3,298,751 pounds of shoddy included nearly six months' imports under the law of 1894, nearly all of it.

The figures of the Treasury show an importation of shoddy of about 118,000,000 pounds in thirty years, nearly three-fourths of which, or about 85,000,000 pounds, was received in this period of a little more than three years. Thus an annual average of nearly twenty times as much was received in the free-shoddy period. In addition to the figures given above those of the two preceding decades should go into this record to facilitate comparison. As manufacturers reckon 1 pound of cloth equivalent to 4 pounds of wool in the grease, and 1 pound of shoddy or waste (cleaned with very small loss in manufacture) equivalent to 3 pounds of wool in the grease, it will be seen that this 85,000,000 pounds of shoddy took the place of 255,000,000 pounds of domestic wool, or nearly one year's product.

*Amount and value of woolen rags, shoddy, mungo, waste, and flocks imported into the United States, 1871–1890.*

| Year ended June 30— | Amount. | Value. | Year ended June 30— | Amount. | Value. |
|---|---|---|---|---|---|
| | *Pounds.* | | | *Pounds.* | |
| 1871 | 1,277,495 | $87,667 | 1882 | 1,097,641 | $358,386 |
| 1872 | 2,719,246 | 232,211 | 1883 | 974,963 | 438,750 |
| 1873 | 1,989,123 | 199,687 | 1884 | 1,316,083 | 564,694 |
| 1874 | 1,783,677 | 151,156 | 1885 | 700,231 | 287,254 |
| 1875 | 1,387,731 | 149,109 | 1886 | 3,059,214 | 1,036,869 |
| 1876 | 243,527 | 45,322 | 1887 | 4,834,636 | 1,843,823 |
| 1877 | 169,925 | 33,265 | 1888 | 4,483,325 | 1,719,154 |
| 1878 | 95,886 | 19,071 | 1889 | 8,662,209 | 3,447,201 |
| 1879 | 92,614 | 22,127 | 1890 | 4,980,327 | 2,052,078 |
| 1880 | 1,388,233 | 297,196 | | | |
| 1881 | 470,873 | 138,363 | Total | 30,579,502 | 11,886,572 |

The theory that dear wool compelled manufacturers to use shoddy and that free wool would obviate its use, has been forever destroyed in this

deluge of material for cloth adulteration. It was a surprise to the theorists, but it is thus explained in the bulletin of the wool manufacturers:

So long as our manufacturers did not have to compete with foreign shoddy-made goods the tendency was rather away from its increased use, for every man's goods found and held a market on their merits. Those who used shoddy did so at their own risk, and their goods passed for what they were. When the Wilson tariff removed the barrier against the importation of shoddy and shoddy goods the situation changed in the twinkling of an eye. More shoddy goods are made in England than in all the rest of the world put together. They have learned there, by long experience, the art of utilizing to the best advantage every kind of refuse that comes from rags and wastes. Let it have but two ends, they will find a way to spin it. These were the goods, among other varieties, which began to pour into the United States when the bars were let down. These were the goods with which American mills had at once to compete. In order to compete it was necessary to use the same kind of materials they use at Batley and Dewsbury. Cheap as wool was, it was not cheap enough to compete with English and continental rags. Deterioration in quality has been the distinguishing result, both as to imported and domestic woolens, of the tariff of 1894.

There was no material change under the law of 1894 in the quantity of carpets, ready-made clothing, or yarns imported. The sophistication and adulteration of our clothing supplies naturally came through cloths, and the abnormal increase was in this class and in women's dress goods. The following is a statement of the number of square yards and value of cloths imported in three-year periods under different tariffs:

*Amount and value of woolen cloths imported, 1892–1900, showing effect of tariff laws.*

| Year ended June 30— | Law of 1890. | | Law of 1894. | | Law of 1897. | |
|---|---|---|---|---|---|---|
| | Amount. | Value. | Amount. | Value. | Amount. | Value. |
| | *Yards.* | | *Yards.* | | *Yards.* | |
| 1892 | 13,813,276 | $12,765,044 | | | | |
| 1893 | 18,206,001 | 15,117,564 | | | | |
| 1894 | 7,456,417 | 6,256,321 | | | | |
| 1895 | | | 23,917,011 | $16,298,169 | | |
| 1896 | | | 36,781,572 | 21,886,528 | | |
| 1897 | | | 27,859,311 | 17,007,273 | | |
| 1898 | | | | | 5,062,261 | $3,965,577 |
| 1899 | | | | | 4,092,898 | 3,909,466 |
| 1900 | | | | | 5,154,674 | 5,129,831 |
| Average | 13,158,564 | 11,546,309 | 29,519,298 | 18,397,323 | 4,769,944 | 4,334,958 |

This shows that the average annual importation of 13,158,564 pounds was increased to 29,519,298 pounds, an increase of about 123 per cent. This is not all, nor the worst. It shows the degradation of quality; that a large part of these goods were mixtures of the lowest order of waste, for notwithstanding the considerable requirement of fine cloths for the higher grades of fashionable tailoring, the mass of importation for the wants of plain people was of so low a character as to reduce the average price per pound for good and bad cloths from about 88 cents to 62 cents, a decrease of 30 per cent. These are the prices abroad, and they indicate the degeneration of

quality of the clothing supply. Added to this flood of foreign goods, the enormous quantities of "wastes" above mentioned kept the shoddy mills in activity day and night, swelling the stocks of worthless goods and forcing the manufacturers of honest cloths into retirement. In the last three fiscal years, not only have imports of woolen cloths fallen to one-third of the amounts imported under the act of 1890, but the increase in value per yard shows the improved quality of the goods imported.

The dress goods of women were greatly increased in quantity, but they were reported in pounds, while under the law of 1890 quantities were stated in square yards, so that comparison of quantities can not be made, but the annual average value of dress goods imports was increased from $13,846,250 to $17,039,070, a large increase, but not at all proportionate to that of cloths, the shoddy element not being so available for women's dress goods.

The total value of imported manufactures of wool was increased under the law of 1894, notwithstanding the lower value of inferior cloths, from an average of $31,017,922 per annum to $47,065,760.

These facts effectually refute the prophecy of a better clothing supply from free wool, and disclose a demoralization of manufactures and deterioration of goods such as never were known in the previous history of the country.

The prophecy that the law of 1894 would result in a full domestic supply of American manufacture, and an export trade in the surplus, was not only discredited but all our markets were glutted with foreign goods. The value of annual exports of all domestic manufactures of wool never rose to $1,000,000 until 1898, under the Dingley tariff. The predicted prosperity of the woolen manufacturing industry as the result of the tariff revision of 1894 failed to materialize, and instead an era of discouragement and disaster set in unparalleled in its history. Secretary North testified of it:

> During a great part of this period the bulk of the woolen and worsted machinery of the country has been wholly or partially idle; much of the remainder has made goods that have either been marketed at a loss or are still in stock. The domestic market for woolen goods has since been in a state of absolute demoralization.

He also declared that "we have in the United States enough woolen machinery, when in operation, to supply all the goods our people can consume."

He further stated:

> The removal of the weight duties of previous tariffs let down the bars to the importation of kinds and grades of cloth hitherto practically excluded from this country, an exclusion greatly to the advantage of our own people, as we now know. The ad valorem basis of the tariff has allowed the importation of the lowest and meanest descriptions of goods made in the world—the peculiar products of the Batley and Dewsbury districts in England, where they have reduced to an exact science the business of making woolens out of shoddy, mungo, wastes, cows' hair, and other

rubbish, in the spinning and weaving of which our American manufacturers have not yet learned the rudiments, although it is clear they will have to learn them if they have got to fight these goods in the home market. Immense quantities of these goods have been thrust upon this market under the present law. They are admirably manufactured, considering the material employed, and while worthless for wear are particularly attractive and deceptive in finish and appearance.

There never was a more total failure of fulfillment of prophecy, or a more complete refutation of an industrial fallacy, than that furnished by American experience with free wool.

As a result of the act of 1894, instead of 50,000 more operatives, half of all were out of employment in 1896, with a great and disastrous loss of wages. The demand for domestic wool was reduced as never before, and prices fell more than half, as stacks of foreign wool were piled up in importing warehouses. Wages, instead of increasing, were not merely reduced, but cut off totally for the multitudes unemployed, to whom employment at half pay was better than starvation.

The losses inflicted upon capital and labor during the industrial depression of these three years were enormous. Capital lost its profit first, and afterwards principal, with shrinkage of values, inability to sell products, and deterioration of idle machinery. Labor lost wages, means of living, comfort, and health. It is not easy to calculate the magnitude of these losses in an industry which by the census of 1890 had attained a production valued at over $300,000,000 per annum. It not only affected the factory population, but indirectly every industry of the country, and was the largest factor in intensifying the depression which reduced all values of real and personal estate, and, with few exceptions, all incomes and means of living. In the full measure of their extent these losses were incalculable and irreparable.

The total losses of this period of three years in the matter of wool and its manufacture alone were probably greater than those of the Spanish war and Philippine rebellion of the last two years; but its consequences were more far-reaching "in destroying confidence and markets," as stated in 1896, in the Bulletin of Wool Manufacturers, so that "other industries, at which the tariff of 1894 struck less vindictively, have suffered and are suffering."

### THE PRESENT CONDITION OF SHEEP HUSBANDRY.

The flocks of the United States do not aggregate so large a number of sheep as in 1893, or in 1884, but they are increasing rapidly, and bid fair to exceed before many seasons the highest former figures. They include a greater variety than at any former period. If manufacturers desire a selection from all the wools in the world, they can get all varieties of much value without going out of the country. That this is no idle boast can readily be proved in our principal wool

markets. A glance at the registry and other breed associations shown in the appendix to the Yearbook of the Department of Agriculture for 1899, will go far to substantiate the same fact. There are the Standard Merino Registry Association, the Vermont Atwood Club Registry, the United States Merino Sheep Breeding Registry Association, the Dickinson Merino Sheep Record Company, the American Merino Sheep Registry, and the American Shropshire Registry Association. Then there are the Vermont Merino Sheep Breeding Association, the New York State American Merino Sheep Breeders' Association, the Ohio Spanish Merino Sheep Breeders' Association, the Michigan Merino Breeders' Association, the National Improved Saxony Merino Sheep Breeders' Association, the Black-Top Spanish Merino Sheep Breeders' Association, the Improved Black-Top Merino Sheep Breeders' Association, the Delaine Merino Sheep Breeding Association, the Improved Delaine Merino Sheep Breeders' Association, the Pennsylvania and Ohio Improved Delaine Sheep Breeders' Association, and the American Rambouillet Sheep Breeders' Association; of the long wools, the American Cotswold Association, the American Leicester Breeders' Association, the American Lincoln Breeders' Association, the National Lincoln Sheep Breeders' Association, and the National Cheviot Sheep Association; of the middle and short wools the various Downs, the Southdown Association, the Oxford Down Association, the Suffolk Association, the Dorset Horn Sheep Breeders' Association of America, and the Continental Dorset Club. And there are others, including an association of breeders of the fat-tailed Tunis sheep.

In collecting the wool exhibit for the Paris Exposition of 1900, the writer was impressed with the wonderful progress that has been made in diversification of breeds and qualities of wool. The same skillful and patient work that resulted in the differentiation of the old Spanish Merino, giving the world the French, Saxon, Silesian, and American Merinoes, has been continued with the latter in the Delaine and Black-Top families (or breeds), with heavier bodies, longer fiber, and more valuable fleece for the finer combing fabrics so much in demand for the fashionable tissues for ladies' and children's wear. The Lincolns, that have played so important a part in the recent breeding of Australia and South America, are here in force and can be produced in any quantity desired, answering the demand for lustrous combing wools.

The wool exhibits now on exhibition at Paris include samples of nearly all breeds and grades of our domestic wool. They fill twenty-one sections, each covered with a plate glass 5 feet in height by 3 in width. Thirteen of these show whole fleeces, twelve in each, from the wool dealers in the two great markets, Boston and Philadelphia, illustrating the various qualities and commercial classifications of

American wools. Seven section cases are filled with samples from breeders of nearly all the breeds, samples of eighty-four fleeces from the farming States, the mountain ranges, and the Pacific coast. More than half are Merino, but the several Delaine breeds outnumber the original American Merinos, illustrating the present popularity and general distribution of the long-fiber combing-wool types, of which the Standard Delaines are the most numerous, representing breeding flocks in Ohio and Texas, one of the latter a fleece from a 2-year-old, weighing 24½ pounds, from W. S. Beck, of Coleman, Tex. The National Delaine exhibits are from Pennsylvania and Ohio, the fleeces being quite uniform in weight—from 15 to 17 pounds—one fleece, from Mr. James S. McNary, of Canonsburg, Pa., weighing 17 pounds. The National Dickinson Delaines are from Ohio breeders, the extreme weight of fleece being 16 pounds. Pennsylvania and Ohio also furnish the Black-Top Delaines, of which one fleece weighs 18 pounds, from Mr. M. M. Keener, of Plaingrove, Pa. There are also Delaines from Missouri, Iowa, and California. The American Rambouillets, with fleeces up to 16 pounds, are from New York, Ohio, and Michigan. The fine Saxony fleeces are from the veteran breeder, Mr. John G. Clarke, of Washington, Pa., one fleece from a yearling weighing 5¼ pounds. Another Saxon exhibit is from Virginia. The larger proportion of Merino fleeces come from California, others from Texas, Indiana, Michigan, Ohio, and New York.

Among the Downs the Shropshires are the most numerous, coming from breeders in Missouri, Iowa, South Dakota, and Oregon, with fleeces up to 12 pounds. Southdowns are from Vermont, Ohio, and Illinois, the heaviest fleece 10 pounds. Oxfords represent Ohio and Illinois, one fleece weighing 14 pounds. Dorset Horn fleeces come from New York, New Jersey, Pennsylvania, and Ohio, and weigh from 7 to 14 pounds. Lincolns, very popular in range districts, are unrepresented. Other exhibits are Cotswold from Oregon, one from the Agricultural College weighing 19 pounds, Leicester and Cheviot from Indiana. There are four samples of the North Star breed from Minnesota, evidently from crossing of fine and long wools, weighing 16 pounds per fleece. As a curiosity a sample of very long fiber from Alaska is included. There is also a case of twenty-four samples of Angora goat fleece, mostly selected by William R. Payne & Co., wool dealers of New York, and coming from W. G. Hughes of Hastings, Tex., John S. Harris of Oakley, Idaho, and George S. Houk of Oregon.

These exhibits will give the people of other countries an idea of the great variety and high character of American wools, and illustrate attainments in breeding that leave little necessity for importing either sheep or wool. There are very few of the breeds of the world worth importing that are not already here, and being improved rather than

deteriorating. Our climates and grasses furnish sufficient diversity and variety to meet all requirements.

From Maine to Texas, from Alaska to Arizona, are found conditions of temperature, humidity, and pasturage, comparatively free from extremes of drought such as have destroyed sheep by thousands in Australia and Argentina, and favorable to great variety and high quality of American wools.

The general feeling at the present time as to the condition and prospects of sheep husbandry is one of relative content and satisfaction, and of confidence and hopefulness for the future. If all growers are not equally suited and satisfied, they are at least measurably content with the situation. The one thing that they dread is a violent change of conditions. In a country that is continental in extent, conditions can not be equally favorable in all sections. There are differences in climate, some districts requiring feed and shelter all winter; others needing neither at any time, except in severe storms that may or may not occur during an entire winter. Some sections have limited pasturage, required imperatively for other kinds of stock; others have broad prairies, or wide stretches of free range.

Western competition has borne heavily on the seaboard States in this as in other branches of animal industry. The effect has been the movement of live-stock industries westward for the past fifty years. As the farm dairy of the Alleghanian slope has existed for the supply of fresh milk to dense neighboring populations, so have sheep been maintained to a limited extent for the production of early lambs, though this industry has suffered from competition since the advent of refrigerator cars.

The decline of flocks has been steady in New England for fifty years. Not only has every decade witnessed a diminution in numbers, as a whole, but in every State the progressive decline has been without a break, with a single exception, Maine having shown an increase in 1880, and a very slight gain in 1860, although there were nearly four times as many sheep in 1850 as in 1900. Vermont in 1850 had nearly half of all the sheep enumerated in the New England States, and while her American Merinos have taken European medals, and have gone to Australia and South America in exchange for generous sums in gold, her flocks declined from 1,014,122 in 1850 to 752,201 in 1860, and 580,347 in 1870, in an era of popularity in which $5,000 was offered and refused for a single sire. This means simply that while there was profit in breeding flocks of high repute, the larger numbers suffered from the general tendency to decline of common flocks. There is a feeling now, among those having former experience, that there may be profit in sheep again for the production of fat lambs, but whether it will lead to increase of flocks is uncertain. With skill and enterprise it might prove so. Few farmers there will be likely to give the requisite attention, and few have pasturage sufficient to support a paying business. If a few get Shrop-

shire or Dorset sires, raise a few crossbred lambs, and sell them for the prices local butchers pay for the common stock, the profit will not prove alluring. There are some, however, who find a profit in such lambs, and more can do the same with the enterprise and energy put into other business in this region.

The conditions in the Middle States are essentially the same as those of the Eastern. The decline in numbers of sheep has been progressive, decade by decade, without a break, except in Pennsylvania, where in 1870 and 1880 increase was shown, owing to prominence of the Panhandle counties in woolgrowing in that period of general prosperity. The decline from 1850 to 1890 was small in Pennsylvania; it was continuous in New Jersey, though there were only 160,488 in 1850; but in New York the falling off was from 3,453,241 in 1850 to 1,528,979 in 1890, and in the last ten years the reduction has been almost half the figures for 1890. Now there are only about a third as many in the Middle States as in 1850—a few breeding flocks, some held for raising spring lambs, and scattered farm flocks. A few can now find a profit under present conditions in pure-bred flocks for fortifying the blood of the mountain-range flocks. The history of the past is no guaranty of future increase, though it may be possible, dependent upon the comparative profit of dairying and other lines of eastern rural industries. The only item of advantage enjoyed by this Atlantic seaboard region in woolgrowing over the far West is in lower transportation charges, and this by no means offsets the advantages of that region.

A letter from the secretary of the New York State American Merino Sheep Breeders' Association, Mr. J. H. Earll, states that flock owners are generally well satisfied with present conditions, as wool at 20 cents and lambs at $4 in July "pay very well." Most of the sheep are of the mutton breeds, the tendency having been in that direction for ten years past. He states that the Shropshire leads all other breeds. In 1888 there were 150 registered fine-wool flocks in the State; now there are about 50. But owners have taken courage from increase of price—from 7 and 8 cents in 1895 to 20 cents in December last, though now temporarily a little lower. They are confident of good prices later.

The Southern States, exclusive of Texas, had between 5,000,000 and 6,000,000 sheep in 1850, and there have been only slight fluctuations since, the census of 1890 showing over 5,000,000. The South has never been a woolgrowing region. Its present opportunity is in feeding lambs and muttons, for which great natural resources are enjoyed—a mild climate that requires little if any shelter and permits the growth of forage all winter, while its cotton seed is a valuable and abundant element of feeding rations. Its population furnishes an extensive market for meats, in which a high quality of mutton, as well as beef, is now scarce. Eastern and foreign markets would furnish a profitable outlet for any surplus that might be produced. In the meat-making branch of sheep husbandry there should be a large increase, climatic

and feeding resources being unexcelled by those of any other States, the most serious obstacles being dogs and an indisposition to undertake new rural enterprises.

Throughout the West a buoyant feeling exists among sheep raisers, and numbers are increasing with considerable rapidity, especially in the valleys of the Mississippi and Missouri. The impulse of growth is felt in all the States of the Ohio Valley.

In Indiana, which has never been a distinctly woolgrowing State, according to Prof. C. S. Plumb the "sheep and wool interests are destined to a very considerable increase." He says it is many years since Indiana has had as many sheep as to-day. In breeding, the value of a good mutton carcass is not lost sight of, while wool is an important consideration. The Rambouillet Merino is now very popular there, and the Delaine Merinos are held in high esteem. The sheep of Indiana are mainly of the mutton breeds, though there is now a tendency to cross with Merinos of large size that approach the mutton conformation. Shropshire grades are now predominant, and many growers incline toward the Rambouillet as an improving cross.

The Secretary of the Indiana Dickinson Delaine Association, Mr. U. C. Brouse, says this breed has been very popular because of a strong constitution, good feeding quality, mutton forms, and heavy fleeces of valuable wool. He says there are about 8,000 registered, mostly in Pennsylvania, Ohio, Indiana, and Michigan.

There is rapid increase of flocks in the prairie States west of the Mississippi. Iowa is perhaps more interested in sheep husbandry than ever before. Sheep are increasing quite rapidly in Minnesota and the Dakotas, and numbers are now greater than at any former period. The feeling is general that under present conditions sheep should prove fully as profitable as any other branch of stock raising.

The region west of the prairies, the range country, including Texas and the Pacific Coast, is the principal area of American woolgrowing. In all this region the industry is now flourishing. Sheep are increasing, the flock masters have the confidence and courage to extend operations, use their time and money in efforts for breed improvement, and give the care and attention to details necessary for the permanent welfare of flocks. Everywhere they appear to be content with the situation.

Advices from Montana and Wyoming, where sheep are counted by millions, and valued as never before, the total value of the flocks of the former being greater than that of any other State, and of the latter only exceeded by that of Ohio, declare a condition of prosperity and contentment. Similar conditions are reported in Utah and Idaho.

New Mexico is credited with the largest number of any State or Territory. The Department of Agriculture estimates 3,397,439; and Governor Otero estimates last year's product of wool at over 18,000,000 pounds and declares that sheep husbandry is now the most prosperous

industry in the Territory and flock masters are in better spirits than for many years. Many years have been occupied in breeding up the coarse-wooled Mexican stock to the Merino plane, yet the wool is still uneven, some fleeces comparing favorably with any in the United States, while the majority are not uniform in grade, running from fine to blanket wool; but each succeeding year the lambs produce a finer grade of wool. A scouring mill in Las Vegas, in its records, indicates this diversity. One clip of 90,000 pounds of grease wool scoured 97 per cent of fine and fine medium, 2 per cent of quarter blood, and 1 per cent of blanket. One of 77,000 pounds of grease wool yielded 90 per cent of fine and medium, 9 of medium, and 1 of blanket. Another of 40,000 pounds scoured 65 per cent of fine and 35 per cent of medium. These indicate a high grade of improvement. Others were not so good. One clip of 31,000 pounds gave only 2 per cent of scoured fine medium, 59 of three-eighths, 17 of quarter blood, 18 of blanket, and 4 of carpet wool. This is coarse but serviceable wool, with little of its original carpet quality.

The industry is also quite prosperous in Arizona, and sheep are increasing rapidly.

The secretary of the National Merino Sheep Register Association, of California, Mr. R. O. Logan, says that woolgrowers are generally jubilant over present prospects, over the return of a fine-wool period, feeling that the tendency of the next decade will be toward the growing of merino wool of long staple. The only serious drawback indicated is the introduction of skirted wools at the rate of unwashed, which reduces materially the protective benefit of the duty.

Oregon and Washington flocks are increasing in numbers, giving a reasonable profit to flock owners and a measure of satisfaction and contentment.

The present condition of woolgrowing has no more suggestive index than the average prices of January last. In the twelve States and Territories which now produce nearly two-thirds of all our wool, the prices of sheep are higher in every one than in January, 1893. In Oregon, Wyoming, and New Mexico the average price was more than double that of 1895, and for all of them together the average was little short of double, and the home price of wool has increased more than 100 per cent. A comparison of January prices in 1893, 1895, and 1900 is as follows:

*Prices of sheep in Far West in 1893, 1895, and 1900, compared.*

| States and Territories. | 1893. | 1895. | 1900. | States and Territories. | 1893. | 1895. | 1900. |
|---|---|---|---|---|---|---|---|
| Texas | $1.60 | $1.21 | $1.92 | Utah | $2.38 | $1.47 | $2.59 |
| Montana | 2.58 | 1.51 | 2.84 | Nevada | 2.43 | 2.42 | 2.91 |
| Wyoming | 2.75 | 1.64 | 3.51 | Idaho | 2.50 | 1.41 | 2.80 |
| Colorado | 2.52 | 1.52 | 2.86 | Washington | 2.83 | 1.74 | 3.13 |
| New Mexico | 1.50 | .90 | 2.17 | Oregon | 2.40 | 1.16 | 2.67 |
| Arizona | 2.25 | 1.21 | 2.34 | California | 2.32 | 1.65 | 2.85 |

Woolgrowers regard with interest the effect of the present tariff on the price of their wools. When the enactment of 1897 went into operation as to wool August 28, 1897, and as to shoddy and other manufactures January 1, 1898, some may have expected an advance equal to the rate of duty. But this by no means occurred. The markets were then full of fine foreign wool, and two or three years of mill consumption were necessary to clear away these stocks. The diagrams (figs. 2 and 3), prepared by Justice, Bateman & Co., wool

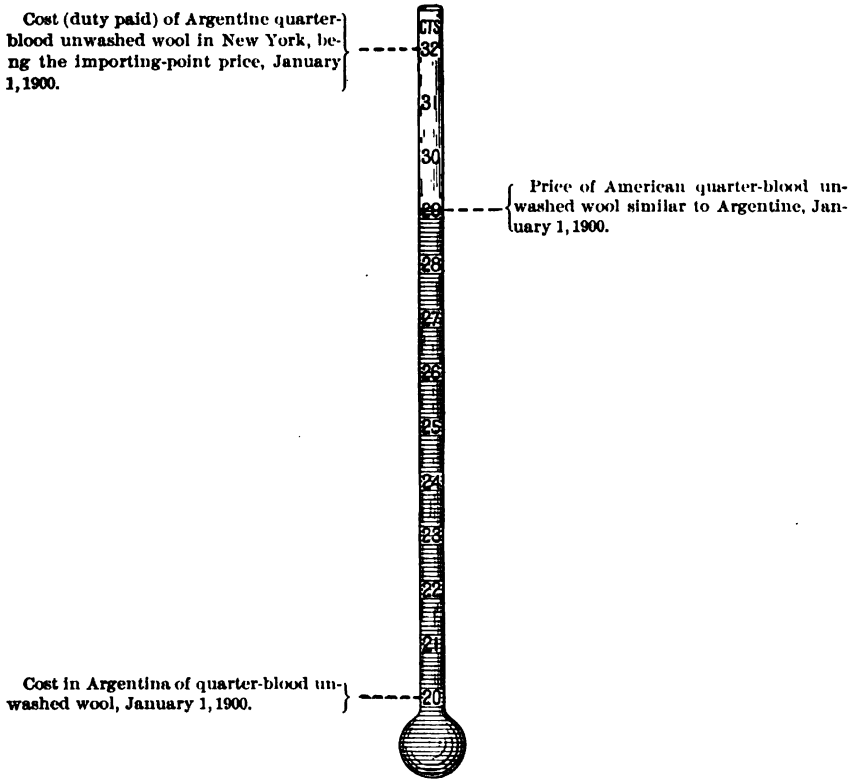


FIG. 2.—Diagram showing effect of Dingley tariff act in raising the price of American wool, January 1, 1900—only three-fourths of its lifting power realized.

dealers, of Philadelphia, illustrate clearly and accurately the price-lifting force of the Dingley tariff. The representative grade of American wool in the diagram is quarter-blood unwashed, which represents wool from mutton sheep of the Shropshire or similar flocks. Fig. 2 shows that only 75 per cent of the price-lifting effect of the tariff was attained by January 1, 1900. Justice, Bateman & Co. say in explanation:

Argentine crossbred wools, spinning to what are known here as 46s to 50s qualities, corresponding to an American medium in the unwashed condition, but skirted, now

cost in the Argentine Republic 20 cents. With 1 cent added for freight the cost afloat in New York would not be under 21 cents, but with the Dingley tariff duty of 11 cents added the cost to the American consumer would be 32 cents for wool of the same class and quality as domestic unwashed medium combing, the outside price for which on January 1 was 29 cents. Thus it would appear that an effort is being made to reduce the duties of the Dingley act before it has had a trial.

This reference to reduction of duties relates to the proposed Argentine reciprocity treaty, which makes a reduction of 20 per cent.

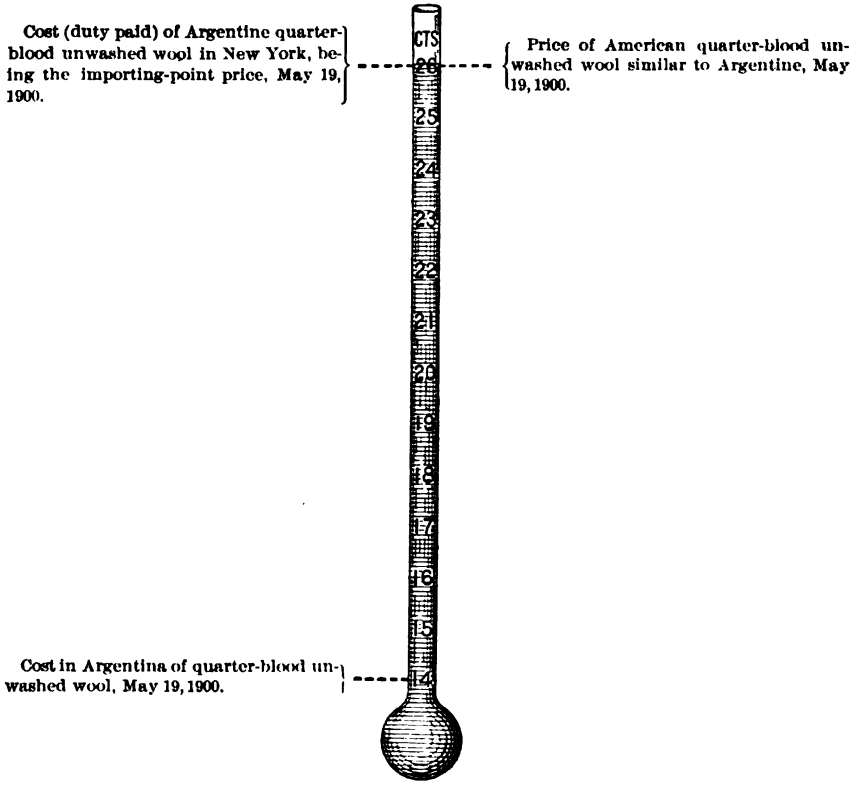


FIG. 3.—Diagram showing effect of Dingley tariff act in raising the price of American wool, May 19, 1900—its full lifting power realized.

Since January 1 there has been a 30 per cent decline in the markets of the world on Argentine quarter-blood unwashed, which realized the full price-lifting effect of the tariff, i. e., the American price is as much above the foreign price as the Argentine price, plus 11 cents duty and 1 cent freight; in other words, it is 12 cents below the American price, which is 26 cents, as shown in figure 3.

Thus it has been between two and three years since the tariff went into force before its full effect could be realized on quarter-blood unwashed wool in comparison with Shropshire or similar American wool.

The data presented in this report show that this country produces wool suited to almost every variety of honest fabric that is made; that, excepting the lower grade of wools, domestic manufacture has at some dates had a nearly full supply; that in a very brief period a full supply of clothing and worsted wools can be reasonably expected. It has also been shown that our manufacturers can not be successful without a comparatively full supply of home-grown wools.

In conclusion, it has been fully demonstrated, and needed not the bitter experience of 1894–1897 for emphasis, that the prosperity of manufacturers is inseparably bound up with that of the woolgrowers. A full supply of wool products for domestic consumption can easily be produced for a constantly increasing population, and ultimately some for exportation is possible, but never with foreign wool. In some lines even now foreign shipments of manufactures of wool are made and they are increasing. During the fiscal year ended June 30, 1900, the value of exports of wool manufactures was $1,253,602 against $1,047,407 in the preceding fiscal year, largely in wearing apparel. This will increase if the prosperity of both industries is maintained.

O

U. S. DEPARTMENT OF AGRICULTURE.

Report No. 67.

# FOREIGN MARKETS

FOR

# AMERICAN AGRICULTURAL PRODUCTS.

TESTIMONY

OF

FRANK H. HITCHCOCK,

*Chief of the Section of Foreign Markets,*

BEFORE

THE INDUSTRIAL COMMISSION.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1901.

# LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF PUBLICATIONS,
*February 1, 1901.*

SIR: On June 13 and 15, 1900, Mr. Frank H. Hitchcock, Chief of the Section of Foreign Markets, appeared as a witness before the United States Industrial Commission by the invitation of that body. His testimony covered especially the relations to and dependence upon agriculture of our foreign trade, and served to bring together in convenient form a large amount of information not hitherto published by the Department. The demand for this information is frequent and widespread, and as the suggestions offered by Mr. Hitchcock in response to the inquiries propounded to him by the Commission are such as have frequently met with your expressed approval, I earnestly recommend the republication of this testimony as a departmental report.

Very respectfully,

GEO. WM. HILL,
*Editor.*

Hon. JAMES WILSON,
*Secretary of Agriculture.*

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# FOREIGN MARKETS FOR AMERICAN AGRICULTURAL PRODUCTS.

## INTRODUCTORY.

At the meeting of the United States Industrial Commission on June 13, 1900, at Washington, D. C., Mr. Farquhar presiding, Mr. Frank H. Hitchcock, chief of the Section of Foreign Markets, United States Department of Agriculture, was introduced as a witness, and, being duly sworn, testified as follows:

Q. (By Mr. A. L. HARRIS.) You may state your name, your address, and your occupation.—A. My name is Frank H. Hitchcock; my occupation is that of chief of the Section of Foreign Markets, United States Department of Agriculture; that is also my address.

Q. How long have you been connected with the Department of Agriculture?—A. Since the autumn of 1891.

Q. And all that time in this bureau?—A. No. I went into the Department as a biologist, passing the civil-service examination. I served in the biological work for one year and then took up the statistical work. I worked in the statistical bureau until about five years ago, when I was transferred to the Section of Foreign Markets soon after its inception. My work has therefore been statistical for about eight years.

Q. Your examination has been exclusively in the line of the extension of foreign markets for agricultural products?—A. Yes; since I have been connected with my present office.

Q. What means have you had for procuring your information in regard to the expansion of foreign markets for agricultural products?—A. We have had, first of all, the published information that is issued by the various foreign governments. We depend upon the official reports, as far as possible, for our information, especially for our statistical information. We have also had the cooperation of the United States consular service through the courtesy of the State Department. The consuls have furnished us with reports on stated topics, the inquiries being transmitted to them through the Department of State. In addition to that we have had some assistance from employees of our own Department abroad. There have been several special agents (so called) employed to study agricultural conditions in foreign countries, and they have reported to the Department. For

information on the subject of our own export trade we are of course dependent very largely upon the reports of our customs officials as published by the Treasury Department.

EXTENT AND INCREASE OF AGRICULTURAL EXPORTS.

Q. You may state, if you will, in your own way, the past conditions of the foreign markets for agricultural products, the present conditions, and the hopes for the future.—A. The extent to which American farmers depend upon foreign markets for the disposal of their surplus products may be gathered from the fact that during the past fiscal year, 1899, our agricultural exports reached in value close to the enormous sum of $800,000,000. The agricultural exports probably comprise about 25 per cent of the total production of American agriculture. With this enormous surplus the acquirement and maintenance of a ready foreign market is of the greatest importance to our agricultural interests. In order to prevent the glutting of the home market we must ship our surplus produce to foreign countries.

During the last forty or fifty years our agricultural exports have increased with great rapidity. In 1860 their value was about $258,000,000; in 1870 it amounted to $363,000,000;[1] in 1880 to $693,000,000; in 1890 to $635,000,000; and in 1899 to $793,000,000. Comparing 1860 with 1899, the last year for which we have figures, a period of about forty years, we find an increase of over 200 per cent.

Every indication points to the probability of a still further increase in our agricultural export trade, providing proper measures are taken to foster it. Modern transportation facilities are revolutionizing the character of the trade. The introduction of cold storage and of refrigeration service on railway cars and steamships is making it possible to market in foreign countries across the sea products that we were formerly unable to export; and it is along this line of development that the increase of our export trade in agricultural products in the future may be chiefly expected—in the exportation of perishable products, such as meats, butter and cheese, perishable vegetables, and fruits.

FRESH BEEF.

Thus far the chief example of trade development along this line is found in the case of fresh beef. In 1880 our exports of fresh beef were valued at about $7,000,000. Last year, 1899, they were valued at $24,000,000.

INDIAN CORN.

Some of the other products that show an increased exportation, but mainly for other reasons, I will now mention. Corn is a notable

[1 The figures for 1870, quoted in this testimony, represent the currency export values, as originally published in the official customs returns.]

example. In 1870 we exported a little over $1,000,000 worth of indian corn. Last year we exported nearly $70,000,000 worth. The development of the dairy industry all over the world and the discovery in foreign countries that American corn forms a cheap and desirable feed stuff for live stock have led to an enormous increase in our exportation of that grain.

### WHEAT FLOUR.

Another conspicuous example of increase is wheat flour. Going back to 1870 we find that the exports of wheat flour were valued at about $20,000,000. Last year, 1899, they were valued at $73,000,000. The remarkable development of the milling industries in this country, resulting in a very large production of high-grade flour at a low cost, has made it possible for us to export flour in competition with other producing countries and gradually to get the trade. Flour affords one of the most notable instances of increase among our agricultural exports.

### CATTLE.

Another case of development in the agricultural export trade is that of the shipment of cattle. In 1870 our cattle exports amounted in value to less than $500,000. In 1899 they amounted to over $30,000,000. This trade has been greatly aided, of course, by the changes in the methods of transportation, the improvement of transportation facilities, the shortening of the time in which live cattle can be transported, not only across the continent but across the sea, and by the measures that have been taken by the Government to protect and foster the trade. The official inspection of export cattle, guaranteeing a standard in condition and quality, has greatly benefited the export trade.

### CURED MEATS.

Our exports of cured meats have also increased to a noticeable extent. The various pork products, in particular, have presented a very marked example of increase. In 1870 we exported only about $6,000,000 worth of bacon and hams, while in 1899 we sent abroad over $60,000,000 worth. Our bacon exports for 1899 were valued at $42,000,000, and our ham exports at $21,000,000.

### LARD.

Similarly the exports of lard have grown enormously in the period under consideration. In 1870 we exported about $6,000,000 worth of lard. In 1899 we exported $42,000,000 worth. The growth of the packing industry in the United States and the improved methods of packing that have been adopted here have resulted in a great development of this export trade.

OIL CAKE.

Another agricultural export that shows a very large growth and a very rapid one is oil cake and oil-cake meal. In 1870 we exported about $3,500,000 worth of oil cake and oil-cake meal. Last year we exported $14,500,000 worth. This product presents a case somewhat similar to that of the exports of corn. It is beginning to be fed very largely to live stock abroad, especially in dairying countries. Foreign dairying interests are beginning to discover its utility as a feed and are importing it in rapidly increasing quantities.

COTTON-SEED OIL.

Another article that shows a rapid increase is cotton-seed oil. In 1870 we exported only about $15,000 worth of this product. In 1899 we sent abroad about $12,000,000 worth.

OLEO OIL.

Oleo oil, a product that has come to the front somewhat recently, affords another instance of growing export trade. In 1870 no exports were recorded. In 1880 about $2,000,000 worth went to foreign markets, and in 1899 over $9,000,000 worth. Oleo oil is sent abroad to countries that manufacture oleomargarine; it is sent abroad in the crude form and is used in the manufacture of imitation butter.

FRUITS.

Still another item is fruits. Our export trade in fruits has increased with considerable rapidity during these years. In 1870 we shipped to foreign countries about $500,000 worth, whereas in 1899 we exported nearly $8,000,000 worth.

The leading articles just enumerated are the ones that have contributed most to the general increase I spoke of as having occurred in our agricultural export trade.

REASON FOR SELECTING STATISTICS QUOTED.

Q. (By Senator KYLE.) Why is it you take a period of thirty years—1870 to 1900?—A. One reason is that the statistics prior to 1870 are not in such satisfactory shape. I have here the figures for each decennial period from 1870 down to 1899.

Q. Is there a falling off in the different periods between 1870 and 1900?—A. There is a fluctuation in some cases—a falling off followed by a recovery.

Q. And then a rise again in the last two or three years?—A. A rise occurred in many cases during the last two or three years.

DISTRIBUTION OF EXPORT TRADE.

Q. I would rather like to hear the destinations of these agricultural products, if you can give them just as well as not.—A. As regards the

distribution of our agricultural exports in general, I will say that the United Kingdom is, of course, our most important market. We send over one-half of all our agricultural exports to the United Kingdom of Great Britain and Ireland. Of the products exported during the five years 1894–1898, measured in value, about 55 per cent went to the United Kingdom. Thirteen per cent of the exports for the same period went to Germany; to France, 6.6 per cent; to the Netherlands, 4.3 per cent; to Belgium, 3.6 per cent. These five countries are the destinations of a very large proportion of our European trade, and, in fact, of our total export trade in agricultural products.

Q. Why do you select the period of 1894 to 1898?—A. The reason I have selected that period in this testimony is because I have published a report upon our agricultural export trade for those years, from which I am able to quote. The report was issued some little time ago, and so it does not include 1899. Similar statistics covering 1899 have not yet been published.

Q. Do these percentages materially differ as regards other periods?—A. Not materially. I am speaking now in reference to the present status of the export trade, and it is fairer to take a period of several years and give the average than to quote any single year. The average for the five years 1894–1898 gives a fairly accurate idea of the present distribution of the export trade. Of our agricultural exports for that period about 88 per cent went to European countries. That shows how important Europe is to us as a market.

Q. You figure with that, of course, the export trade from the Pacific coast?—A. The entire agricultural export trade of the United States.

### INCREASE OF TRADE TO ASIATIC COUNTRIES.

Q. Do you think in the period from 1894 to 1898 there has been an increased trade from the Pacific coast to the Asiatic countries?—A. There has been a marked increase during that period. The total value of our agricultural exports to Asia increased from less than $4,000,000 in 1894 to nearly $15,000,000 in 1898. The agricultural exports to Oceania, which are stated separately, increased in the same period from less than $2,000,000 to $3,500,000—quite a material increase. The increase shown by the Asiatic and Oceanian trade is proportionately very much greater than the increase shown in any other direction. It is about the most interesting feature of our recent foreign-trade development.

### COTTON.

Q. What are the branches of our trade that are increasing in the last three or four years from the Pacific coast?—A. As regards the agricultural exports, the chief articles are cotton and wheat flour. I will quote from one of my reports statistics to show how the export trade in cotton has developed. Our total exports of raw cotton to

Japan, China, and Hongkong increased from 23,500 pounds in 1889, ten years ago, to nearly 119,000,000 pounds in 1898. The present trade represents the growth of little more than a decade. To show how rapidly it has developed in the last year or two, I will say that in 1897 the exports amounted to only 32,000,000 pounds, as compared with nearly 119,000,000 pounds in 1898.

Q. Have you any figures to show the increase of the production of China during this same period? Were they increasing materially in the production of cotton?—A. Not materially. Very little increase is shown by the statistics of cotton production in China.

Q. So that the inference, then, is that they are wearing more cotton, they are consuming more cotton goods?—A. The raw cotton, I will say, goes chiefly to Japan, where the manufacturing of cotton is rapidly coming into great prominence. The Japanese are now manufacturing enormous quantities of cotton goods. Their manufacturing has increased very rapidly in the last few years, and they are now drawing upon us quite extensively for their raw cotton. The natural inference would be that the use of cotton cloths is increasing in that portion of the world.

Our gains in exportation, however, are not confined entirely to the exports of the raw product. Our exports of cotton manufactures to the Orient also show a considerable increase. They have fluctuated considerably from year to year, but taking 1889 to 1898, a period of ten years, we find an increase from $1,600,000 worth in the former year to $5,300,000 worth in the latter year.

Q. Just in one year?—A. No; in ten years.

Q. In ten years an increase of $4,000,000. Well, is this a peculiar kind of cotton goods?—A. It is the style of cotton goods, of course, that is generally sent to tropical countries, largely cheap cottons of the coarser grades.

Q. From what section of the United States are these goods exported?—A. They come from the cotton manufacturing sections in New England and also from the South. I do not know as to the exact distribution, but I understand that the South is now beginning to export quite largely to the Orient.

Q. The South is manufacturing an article that is very largely consumed in the Orient, is it not?—A. I understand it is beginning to.

### WHEAT FLOUR.

I spoke also of the exportation of wheat flour to the oriental countries; I will quote statistics to show the gain in the shipment of that product. In 1889 our exports of wheat flour to Japan, China, and Hongkong amounted to 408,000 barrels. In 1898 they amounted to 1,120,000 barrels. The increase was particularly marked in the last

few years of the decade. In 1894 they had increased to only 676,000 barrels; the advance to over a million occurred in the years following that.

DESTINATIONS OF LEADING EXPORTS.

At Senator Kyle's request I will now take up the leading products I have mentioned as showing gains in exportation and state briefly the principal destinations to which we are now sending them. Indian corn is the first item on my list. I will ask Senator Kyle whether he would prefer to have me state the distribution by quantities or by values?

Senator KYLE. I think value probably would be a sufficient indication.

Q. (By Mr. A. L. HARRIS.) Have you the bushels or weights in your statement?—A. I have both quantity and value wherever they can be stated. In the case of some items—for instance, fruits—only the value is recorded.

Q. (By Mr. FARQUHAR.) In the case of cereals, however?—A. The separate cereals are all stated by both quantity and value. To get at the volume of the exports it would be important, of course, to have the quantity as well as the value; but where you are simply showing the proportion of export trade that goes to the different countries the value forms a satisfactory basis as regards the distribution. In fact it makes very little difference in a given year whether we take the quantity or the value for that purpose. Such statements, whether stated in quantity or in value, are merely comparative. However, I can quote, if you wish, both quantities and values.

Mr. FARQUHAR. I think the commission would like to have both the quantity and the value.

WITNESS. To give a fair idea of the distribution I will take the average for the five-year period 1894–1898, stating the quantity and value for that period.

INDIAN CORN.

Speaking now of indian corn, our shipments of this grain to the United Kingdom averaged 50,000,000 bushels a year, the value being about $18,000,000. That gave the United Kingdom, taking the percentage of quantity, about 43 per cent of the total exports. Germany ranked next to the United Kingdom as a market for our corn, taking about 20,000,000 bushels a year, or about 17 per cent, the value being slightly more than $7,000,000. Canada was a market for about 10,500,000 bushels, the value being about $3,700,000. Canada took about 9 per cent of the total. The Netherlands, with 10,400,000 bushels, valued at $3,800,000, received nearly 9 per cent. Denmark took nearly 8 per cent, receiving about 9,000,000 bushels, with a value of about $3,000,000. These five countries—the United Kingdom, Ger-

many, Canada, the Netherlands, and Denmark—were the chief markets for our indian corn during the period under consideration. After these countries France and Belgium may be cited as the most important markets.

### WHEAT FLOUR.

Wheat flour is the next item that I will mention. Of the wheat flour exported in the five-year period 1894–1898, the United Kingdom took about 58 per cent. The quantity sent to that country was, taking the annual average, about 9,000,000 barrels and the value about $35,000,000. Other destinations, the chief of which, however, the Netherlands, took only about 6 per cent, were, in the order of their importance, the Netherlands, Hongkong, Brazil, Canada, the British West Indies, Cuba, and Germany. I have mentioned all the destinations to which an average annual export of more than 200,000 barrels was sent.

Q. (By Senator KYLE.) Did you mention the Asiatic countries there in that list?—A. I mentioned the chief one—Hongkong. Hongkong ranks third.

Q. About what per cent?—A. It takes about 5 per cent of the flour.

Q. I would like to ask you whether the East Indies are finding a market for wheat and wheat flour in the Orient?—A. My impression is that they are not to any considerable extent. You refer to India?

Q. India; yes.—A. Not to any large extent. India is not developing as a wheat-exporting country. That country has not the importance that it formerly had as a source of supply. I have here the wheat production of British India. It fluctuates, of course, from year to year, but the general tendency has been downward.

Q. You may state for the information of the commission something about the production of British India.—A. There have been indications that the wheat production of India was declining, if anything, in recent years. For instance, the average annual production for the past five years, 1895–1899, amounted to something less than 230,000,000 bushels, whereas the average for the preceding five years, 1890–1894, was about 240,000,000 bushels. The average for the five years 1885–1889 was still larger, amounting to about 260,000,000 bushels.

### CATTLE.

I was about to speak of the distribution of our export trade in cattle. The United Kingdom takes nearly 95 per cent of the live cattle shipped from the United States. The average number of head exported to the British market during the five years 1894–1898 was about 350,000 and the value about $33,000,000. It is the only market of importance we have for export cattle. The remainder of the trade is widely distributed among other countries.

I will mention as an interesting fact that we have recently been shipping quite a number of cattle to Cuba. In 1898 we shipped about 40,000 head. The importation of American live cattle into Germany, France, Belgium, and the Netherlands was prohibited some years ago, although I should say that Belgium has since removed the prohibition.

Q. (By Mr. A. L. HARRIS.) What was the reason of the prohibition?—A. The prohibition was enacted on the supposition that there was danger of introducing infectious diseases. Several years ago—I believe it was in 1894—there were some alleged cases of Texas fever in American cattle shipped to Hamburg. On the strength of that Germany prohibited the importation of live cattle from the United States, and these other countries afterwards took similar action.

Q. What action has been taken, if any, on the part of our Government to insure against the disease of Texas fever in the shipments from this country?—A. The inspection system of the Department of Agriculture is believed to be a very sure preventive of the exportation of diseased cattle. I think there is little danger of sending diseased cattle cut of this country under that system.

Q. But so far you have not been able to convince those countries that there is no danger?—A. There has been a great deal of correspondence between our Government, through the State Department, and foreign governments on that subject, but it has been very difficult to convince them. I do not know whether I should say this formally or not. I should like to say to the committee, informally, that it is believed to some extent that the restrictions put upon our exports are simply a pretext to keep them out in order to prevent competition. That is one reason why it has been so difficult to get some of these restrictions removed.

Q. (By Mr. FARQUHAR.) Is the action of Germany traceable to the so-called Agrarian party, or the Farmers' party, in the exclusion of the American product?—A. It is generally believed that the Agrarians are back of all these movements against our products, and that the real object is not so much to protect the German people from injury through disease as it is to protect their products against competition.

Q. (By Mr. A. L. HARRIS.) Where is the estimate of value placed, here in this country or where the cattle are delivered?—A. In the statistics I am quoting the value is the declared value here.

Q. (By Mr. FARQUHAR.) In the American custom-houses?—A. In the American custom-houses. I am now using United States statistics. The Germans, in preparing their statistics of importation, take the value in their own ports, based on the market price.

LARD.

The next product I have on the list is lard. The United Kingdom is also the chief market for our lard, Germany ranking second. A

large part of the lard is sent to those two countries. During the period 1894–1898 the United Kingdom annually took about 194,000,000 pounds on the average, the value being about $13,000,000. Germany took during the same period about 144,000,000 pounds, valued at $9,000,000. The United Kingdom's proportion of our total lard exports was 36 per cent and Germany's 27 per cent. We also shipped considerable lard to the Netherlands and Belgium. The average yearly shipment to the Netherlands was about 45,000,000 pounds, with a value of $3,000,000; that to Belgium was about 33,000,000 pounds, valued at about $2,000,000. The Netherlands took about 8 per cent and Belgium about 6 per cent of the total. Among other countries to which we shipped in lesser quantities were Cuba, France, Brazil, and Denmark.

Q. (By Senator KYLE.) What percentage did France take?—A. France took about 5 per cent.

FRANCE AS A MARKET.

Q. In your list of destinations you mention England, Germany, Belgium, and the Netherlands, and seldom ever include France among them. What is the reason that France consumes such a small proportion of American products? Do they produce largely in all these lines?—A. France, of course, is to a very large extent an agricultural nation, producing from its own soil an abundant food supply, and so we have always found it difficult to market our agricultural products there. The difficulty is increased by rather stringent tariff legislation enacted in the interests of French agriculture. I think there is also, to a certain extent, a prejudice in France, as in Germany, against some American products, especially meat products. At any rate, it has been the history of the trade that the French have not taken their proportion of our meat products.

Q. Not even considering the question of obstruction?—A. I think not.

HOGS.

Q. You bring in the hog before you get through, do you not? I would like to have that next to the lard; the hog is a very important institution in this country.—A. The hog is certainly a very important institution in this country, but it is not sent out alive to any considerable extent.

Q. Goes as pork, of course?—A. It goes in the form of pork; the packing is done here. Our average annual exports of live hogs during the five years 1894–1898 amounted to only about 14,500 in number; the value was about $144,000. They went chiefly over our borders to Mexico and Canada. We sent an average of about 10,000 head to Mexico, valued at about $115,000; and to Canada about 2,000 head, valued at about $11,000. We also exported an average of nearly 2,000

head to the Hawaiian Islands, the value being about $10,000. Of the total number of hogs exported, Mexico received 67 per cent, Canada 15 per cent, and the Hawaiian Islands 13 per cent.

FRESH PORK.

Our exports of fresh pork averaged only a little over 3,000,000 pounds a year, and went chiefly to the United Kingdom, the shipments to other countries being inconsiderable. The total value was about $220,000.

SALTED OR PICKLED PORK.

Of pork, salted or pickled, we exported about 70,000,000 pounds a year, the value being about $4,000,000. Of this product the United Kingdom took 22 per cent, the amount being about 15,000,000 pounds and the value about $1,000,000. The remaining exports of salted or pickled pork went chiefly to Haiti, Canada, British West Indies, Porto Rico, British Guiana, and Germany.

Q. Germany comes last in the list in regard to importance?—A. I have named only the most important countries; there are many other countries, of course, of lesser importance.

Q. Is Germany named in the order of importance?—A. Yes; they were all named in the order of importance.

Q. Germany tailing the list?—A. Germany took a little over 3,000,000 pounds a year during that period, the value being about $200,000. Germany's share was less than 5 per cent of the total.

BACON.

Of bacon we exported annually about 490,000,000 pounds on an average, and the value was about $38,000,000. The United Kingdom took of this amount about 77 per cent, or 377,000,000 pounds, valued at $30,000,000. We sent 31,000,000 pounds, or about 6 per cent, to Belgium, the value being $2,300,000; to Germany we sent about 5 per cent, or 23,000,000 pounds, worth $1,500,000. We shipped about 16,000,000 pounds to Brazil, or slightly more that 3 per cent, the value being $1,200,000. The Netherlands took about 2 per cent, or 11,000,000 pounds, valued at $800,000. These five countries were the leading destinations.

HAMS.

Of hams we exported about 137,000,000 pounds a year, the value amounting to about $13,700,000. The United Kingdom took 111,000,000 pounds, valued at $11,000,000, this being 81 per cent of the total. After the United Kingdom, Belgium was the most important market, taking about 8,800,000 pounds, valued at $860,000, or about 6 per cent. We shipped about 4,000,000 pounds a year to Cuba, the value being $435,000; Cuba took about 3 per cent of the total. To Germany

we also sent about 4,000,000 pounds, or 3 per cent, the value being $383,000. To Canada we sent about 2 per cent, or 3,000,000 pounds, worth $292,000. The only other country that took hams to the extent of 1,000,000 pounds a year was the Netherlands, the shipments to that country averaging about 1,400,000 pounds, or slightly more than 1 per cent of the total, the value being about $147,000.

### OIL CAKE.

Another item I mentioned as being of interest because of the rapid growth of its exportation was oil cake and oil-cake meal. The exports are recorded under two heads, oil cake and oil-cake meal made from cotton seed and that made from flaxseed or linseed.

As to the cotton-seed oil cake or oil-cake meal, we shipped of this product annually during 1895–1898 about 609,000,000 pounds on an average, the value being about $5,400,000. It was sent chiefly to Germany and the United Kingdom, the former country taking about 47 per cent of the total, or 289,000,000 pounds, valued at about $2,600,000, and the latter country, the United Kingdom, about 27 per cent, or 165,000,000 pounds, valued at $1,400,000. After these two countries the most important market was Denmark, which took on an average about 11 per cent of the total, or 66,000,000 pounds, worth $585,000. To the Netherlands we sent 57,000,000 pounds, worth $518,000, or about 9 per cent; to Belgium 17,000,000 pounds, worth $150,000, or about 3 per cent; and to France 12,000,000 pounds, worth $100,000, or about 2 per cent. The shipments to other countries were comparatively unimportant.

Now, taking up flaxseed oil cake and oil-cake meal, we sent of this product to foreign markets about 377,000,000 pounds, the value being close to $4,000,000. The United Kingdom received about 48 per cent, or 181,000,000 pounds, valued at nearly $2,000,000; Belgium about 26 per cent, or 98,000,000 pounds, valued at $1,000,000; the Netherlands about 14 per cent, or 54,000,000 pounds, worth $571,000; and France 5 per cent, or 17,000,000 pounds, valued at $172,000. To Germany we shipped 12,000,000 pounds, or about 3 per cent, the value being $126,000. We also sent about 3 per cent to the British West Indies, which took 11,700,000 pounds, worth $136,000. These were the most important markets for flaxseed oil cake and oil-cake meal.

### COTTON-SEED OIL.

I also mentioned cotton-seed oil, stating that the exports of this product amounted to about $12,000,000 in value for the year 1899. The average for the five years 1894–1898 was about $7,000,000 in value, and in quantity about 25,000,000 gallons. Of these exports, we sent to France 6,700,000 gallons, worth $1,800,000, or about 27 per cent of the total.

Q. (By Mr. KENNEDY.) There must have been a remarkable growth in the exportation of cotton-seed oil; for the year 1899 you say it was $12,000,000, while the average for the five years 1894–1898 was $7,000,000. Where did the increase come; all along, or was it remarkable for any one or two years?—A. There was a marked increase in 1898 and 1899. There was a considerable increase in the preceding years, but in the last two years there was a very decided increase. The quantity exported increased from 27,000,000 gallons in 1897 to 40,000,000 gallons in 1898 and to 51,000,000 gallons in 1899.

Next to France in importance as a market for cotton-seed oil comes the Netherlands, to which country we exported during 1894–1898 an average of about 5,800,000 gallons a year, or about 23 per cent, the value being nearly $1,800,000. After France and the Netherlands, which took over half of the total, the principal markets were the United Kingdom, Germany, Austria-Hungary, Mexico, and Italy. We sent to the United Kingdom about 9 per cent, or 2,200,000 gallons, worth $595,000; to Germany about 8 per cent, or 2,000,000 gallons, worth $648,000; to Austria-Hungary also about 8 per cent, or nearly 2,000,000 gallons, worth $572,000; to Mexico about 6 per cent, or 1,500,000 gallons, worth $336,000; and to Italy about 5 per cent, or 1,300,000 gallons, worth $382,000. These were the only countries to which we sent average annual exports exceeding 1,000,000 gallons.

### OLEO OIL.

Another product for which I will give statistics of distribution is oleo oil. Our exports of oleo oil for the five years 1894–1898 averaged about 110,000,000 pounds, and the value about $8,357,000.

Q. (By Senator KYLE.) What was the average exportation of butter during these years, and also give the valuation.—A. The average exportation of butter was 18,764,000 pounds and the value about $2,858,000.

Q. As against 110,000,000 pounds of oleo oil?—A. Yes. Of these exports of oleo oil, the Netherlands took about 60 per cent, the average quantity being about 66,000,000 pounds and the value about $5,000,000. Germany was the second market in importance, taking 23 per cent of the total, or about 25,000,000 pounds, with a value of about $1,900,000. Our exports to the United Kingdom, which ranked third as a market, averaged 8,000,000 pounds, or about 7 per cent, the value being $645,000. To Sweden and Norway we sent about 4 per cent, or 4,320,000 pounds, worth $300,000, and to Denmark about 3 per cent, or nearly 3,000,000 pounds, worth $233,000. Belgium took slightly more than 1 per cent, or 1,400,000 pounds, the value being $110,000. Shipments to other destinations were comparatively small.

The oleo oil exported to the Netherlands is used chiefly for manufacturing oleomargarine, or imitation butter, which forms an extremely

important industry there. In some of the other countries I have mentioned our oleo oil is used quite extensively for the same purpose.

## EXPORTS OF DAIRY PRODUCTS.

### DECREASE OF AMERICAN BUTTER EXPORTS.

Q. (By Mr. A. L. HARRIS.) You may state, if you can, what effect this increase in the export of oleo oil had on the dairy interests of the country.—A. I was about to refer to the exportation of the dairy products, butter and cheese, as presenting the most striking example of decline in our agricultural export trade. I have tried to cover some of the most important instances of increase in the products I have already mentioned. Butter and cheese present the most striking cases of loss, and to illustrate the falling off that has occurred I wish to give a few figures from our export records. Going back to 1880 we find that there was an annual export of nearly 40,000,000 pounds of butter. I will give the exact figures, which are 39,237,000 pounds, valued at $6,691,000. That year represented about the height of our export trade in butter. In 1890 the exports were 29,748,000 pounds, valued at $4,187,000, a decline of nearly 10,000,000 pounds for the decade. In 1895 our exports had dropped as low as 5,599,000 pounds, valued at $916,000. That was about the low-water mark in our butter export trade. For the last two or three years the trade has been picking up a little. In 1899 we exported about 20,248,000 pounds, worth $3,264,000.

Q. (By Senator KYLE.) Still very much less than in 1890?—A. Only about one-half what we exported twenty years ago.

### CAUSES OF DECREASE OF AMERICAN BUTTER EXPORTS.

Q. (By Mr. A. L. HARRIS.) Is that quantity accounted for solely on account of the increase of the export of oleo oil?—A. No.

Q. To what other cause can you attribute that falling off?—A. Of course the increase in the production of imitation butter and its increased consumption abroad have naturally affected the consumption of butter, but they have not caused this great falling off in our export trade. In spite of the increased consumption of butter substitutes there has been an increased exportation of butter from most of the dairy countries. They have increased their trade while ours has been dropping off. The chief cause of this decline is found in the unfortunate management of our export trade. The chief cause of the decline was the inferior grade of butter that our exporters sent to foreign markets, and especially to the United Kingdom, which is our chief butter market. After we had established a trade of considerable importance and created a fair reputation for our butter in the foreign market, unscrupulous exporters began to take advantage of the situa-

tion to dispose of inferior butter, and the lack of any Government inspection of export butter in this country made it possible for them to ship almost any kind of butter. What I suppose you might call adulterated butter—process butter—renovated butter—they were able to label as they pleased, and large quantities began to be sent to the English markets, and this naturally brought the American butter as a whole into disrepute. I should have said in the first place that as a rule we did not send our best butters to the British market; inferior grades that could not be readily disposed of in our domestic market were sent abroad in large quantities, and it is generally admitted that this was the cause of the loss of our export trade in butter.

Q. Any recent tariff discriminations, or anything of that kind?—A. No. Our chief market, you see, is the United Kingdom, where butter is admitted free of duty.

INCREASE OF DANISH BUTTER EXPORTS.

In contrast to this decline in our own export butter trade was the experience of certain other butter-exporting countries, and especially Denmark. In 1880, the first year I referred to as regards our own exportations, the Kingdom of Denmark exported about 27,498,000 pounds of butter, having a value of about $6,305,000. By 1890 the Danish exports had increased to 98,373,000 pounds, worth $20,808,000. In 1898, the last year for which we have their export returns, Denmark exported 160,143,000 pounds, worth $34,576,000.

Q. Where did Denmark find the market chiefly?—A. Denmark sends her butter almost exclusively to the British market—the greatest butter market of the world. Denmark caters to that market, and makes her butter with a special reference to its requirements. Only a very small per cent of Danish butter goes to other destinations.

Q. What percentage of the oleo oil does Denmark take?—A. About 3 per cent.

Q. Our people, then, have discredited their own product?—A. Exactly.

GOVERNMENT SUPERVISION IN DENMARK.

The butter export trade of Denmark is practically under Government supervision. It has been the policy of the Danish Government, first of all, to establish a reputation for its products in foreign markets, and then to compel its producers and exporters to maintain the high standard of those products.

Q. Please state how they succeed in enforcing that requirement. Do they have inspections at the borders?—A. Yes; the butter for export is carefully inspected, under the direction of the Royal Agricultural Society, acting for the Government, and no butter is allowed to go out of Denmark that does not come up to the required standard. It is a remarkable fact that Danish export butter is all of one grade.

The importers in England simply give an order for so much "Danish butter" at the market quotation. This fact speaks volumes for the character of the product that is shipped from Denmark.

Q. (By Senator KYLE.) Very similar to our buying the Elgin butter in this country, is it not?—A. Somewhat similar to that, perhaps.

VALUE OF GOVERNMENT CERTIFICATE.

Q. Elgin creamery butter—people know what that means when they ask for it and pay for it?—A. Yes; but in the case of Danish exported butter the British purchaser practically has a Government guaranty that the butter will be of a certain grade and up to a certain standard.

Q. What have you to say in reference to the United States inspection?—A. We do not have any such thing as regards export butter, and that is the great difficulty; that is exactly what we need. I believe we should have a system of Government inspection for dairy products similar to that applied to our meat exports; and, in fact, our Secretary of Agriculture, Mr. Wilson, in his last annual report recommended that such a system be established, requiring our export butter to be inspected and labeled as to grade and sent abroad with the Government certificate upon it, guaranteeing to the foreign purchaser that the butter is of the grade claimed by the exporter, and thus preventing the fraud now possible in the exportation of this product.

Q. And that it is butter and not oleomargarine?—A. Certainly.

Q. It would be a very good thing if we could get the same guaranty for the American consumer?—A. Yes.

INCREASE OF BUTTER EXPORTS FROM CANADA.

In Canada they are adopting a policy very similar to that in vogue in Denmark.

Q. (By Mr. KENNEDY.) Where does the Canadian butter go?—A. It also goes chiefly to England.

Q. (By Mr. FARQUHAR.) How many years is it since Canadian butter and cheese have run American butter and cheese out of the English market?—A. I spoke of 1880 as being within the period of our greatest development in the butter trade.

Q. That was the high-water mark?—A. As regards butter, yes. I do not refer to Canada as a competitor in the butter export trade especially. It is in the cheese export trade that we have lost to Canada. The Danes have developed the butter export business much more extensively than Canada, although latterly the Canadians are taking steps to push their butter export business, just as they have been doing with the cheese export business.

Q. Can you give figures to show how far the Canadians have come into the United States market with butter product, even as against the tariff?—A. Only to a very small extent. I have not the exact figures here. Their total exports of butter are not large, however, although

they are now beginning to develop. In 1899 Canada exported to all destinations about 20,000,000 pounds of butter, the value being about $3,700,000. In 1890 very little export business was done, less than 2,000,000 pounds going abroad. The Canadian trade fell off at about the same time as that of the United States.

Q. And fell off for the same reason?—A. Presumably the same, although I have not looked into that matter so carefully.

I will quote now the 1880 figures for Canada. In that year Canada exported 18,535,000 pounds of butter, worth about $3,000,000. In 1890, as I have said, the shipments dropped to less than 2,000,000 pounds, the value being only $340,000. In 1899, under the measures taken to reestablish the butter export business, the amount shipped came up to about 20,000,000 pounds. In other words, the Canadians export about as much now as in 1880. That is the history of their trade. Their efforts to push the butter export business are comparatively recent, much more so than their efforts to push the cheese export trade. They are now taking measures similar to the Danish methods to put their butter into the British market, and that is one reason why it is very important for us to take some such measures.

(At this point the commission took a recess until 2 o'clock, and requested Mr. Hitchcock to continue his testimony at 10 a. m. Friday, June 15, 1900, at which time the hearing was continued as follows:)

SUMMARY OF PRECEDING TESTIMONY.

Q. (By Mr. A. L. HARRIS.) Professor, the other day you were testifying in regard to the decline of dairy products. Have you anything more to say in regard to the cause of the decline in dairy products?—A. I called attention to the fact that there was a very remarkable falling off in our exports of butter, beginning soon after 1880, when the trade had reached its high-water mark. I explained that this decline was largely due to the shipment of an inferior and in some cases an adulterated product. In contrast to the falling off in our own export trade in butter I mentioned the remarkable development of the export trade of Denmark, where it has been the policy to permit the shipment of no inferior products. The Danes started in to establish a reputation for their butter, and, having established it, they took measures to maintain it, and the result has been the remarkable growth of trade that I set forth statistically. I also mentioned the fact that Canada has recently taken measures to extend her export trade in butter, and with marked success.

INCREASE OF BUTTER EXPORTS FROM AUSTRALASIA.

I wish also to mention the case of the Australasian colonies of Great Britain. The butter exports from these colonies to the United Kingdom, which is their chief market, increased from less than 4,000,000

pounds in 1889 to over 40,000,000 pounds in 1899. In Australasia measures similar to those carried out in Denmark have been adopted, and results almost as notable in the way of increased trade have followed.

INCREASE OF BUTTER EXPORTS FROM OTHER COUNTRIES.

Other countries that have developed an important export trade in butter within the last decade are Sweden and Finland. These countries produce a butter that is practically the same as Danish butter, and they are shipping it now to the British market in increasing quantities each year. I should explain that quite a large quantity of this butter from Sweden and Finland has hitherto gone to Denmark, being practically the same thing as Danish butter, and a considerable portion of it has undoubtedly been reexported by the Danes as their own butter, with which it is to all practical purposes identical. Even Russia is also beginning to develop an export trade in butter. The Baltic provinces, especially, are giving their attention to this industry, and are taking active measures to develop it—measures similar to those taken by Denmark. The Russians are engaging Danish experts to install their creameries and to instruct their butter makers. Already they are beginning to ship a high grade of butter, some of which is sent to the British market, and finds there a ready sale.

These various countries, none of which has greater dairying possibilities than the United States, are thus developing and widening their export trade in this commodity, while we, because of our unbusinesslike methods, have been losing the little export business that we formerly possessed. I believe that this product as a factor in our export trade should receive special attention. I think it would be profitable to take measures to develop an export trade in butter.

RECOMMENDATION OF INSPECTION.

Q. Could that be best accomplished by legislation, or do you think voluntary associations could bring about the result?—A. I think that legislative aid would be of great assistance. I am strongly in favor of official inspection of exported butter. I think that is the most feasible plan for preventing the shipment of inferior produce.

Q. You would recommend an inspection similar to that that is now required for our meat products?—A. Yes; the same system could be extended so as to include butter and other dairy produce. As I stated at the last hearing, the Secretary of Agriculture has made the recommendation that butter and cheese and milk for export be subjected to an official inspection, that a grade be established, and that produce that comes up to that grade be certified to by the Government inspector, labeled, and the Government certificate placed upon it as a guaranty to the foreign importer of its quality. Such a measure is very strongly recommended by the Department, and I think that it would meet with

the approval of the dairying industry. Some inquiries have been made in this regard and the general feeling, as far as tested, seems to be in favor of Government inspection for these products.

DANISH METHODS WITH BUTTER.

Q. (By Mr. FARQUHAR.) Are you through with the butter?—A. Not fully.

Q. Has the Department of Agriculture made any investigation as to the process of manufacturing butter in Denmark and Sweden in comparison with America and Canada?—A. Yes.

Q. Have you any sufficient, obtainable reports to show the difference in the quality of the milk and cream that enters into the manufacture of the butter?—A. Several years ago the Department sent a special agent to Denmark to investigate the dairying industry. The agent was commissioned toward the close of Secretary Rusk's administration, as I remember. He went to Denmark and spent several months there investigating the dairy methods, and afterwards made a very thorough and comprehensive report, which was published in the last Administration. The Department has not made similar investigations in the other countries you have mentioned.

Q. Was the Denmark manufacture at that time as far progressed as it is now, as perfect?—A. Probably not as perfect, because the Danes are perfecting their system every year, but it had reached a condition that made it rank as the foremost in the world. The Danes are regarded as the pioneers to a certain extent in butter production by modern methods. They have been the models, not only as regards production, but as regards export methods, for these various other countries I have mentioned—these countries that are now developing very rapidly an export trade in butter.

Q. Do you know whether the Danish butter is made from the sour cream or just simply from the milk after having extracted the cream from it, what we call the body of the milk?—A. I am not an expert in the dairy business, but I understand that the Danish butter is made almost altogether from pasteurized cream; a very large percentage of the Danish butter is pasteurized, and to that fact is attributed its remarkable uniformity.

Q. In other words, it is a cream butter?—A. Oh, yes; it is a cream butter.

OPPORTUNITY FOR INCREASING AMERICAN BUTTER EXPORTS.

Q. Is it possible under any inspection for the American butter to compete with the cream butter of Europe? Has the Department discovered that, or has it gone into the investigation of it?—A. The Department thinks it is possible for us to put a butter into the British market that is equal in quality to the Danish.

Q. Certainly, provided that they take the same class of cream to

make the butter, but no other way?—A. Of course, it goes without saying that they would have to use an equally good material.

Q. Is it not a fact that you have investigated that really the Americans are putting a butter there that has not the full fatty substance of butter and is not perhaps equal to the cream butter of Europe, to the English, Scotch, Irish, or Danish?—A. In the past that was the great difficulty with our export trade. Our butter was often of an inferior quality. That can not be denied.

Q. Inspection would not improve it?—A. Inspection would not improve the inferior butter, but the idea, as I understand it, is to establish a high grade. Butter that reaches that grade will carry a certificate. Inferior butter will go without a certificate. The foreign importer, knowing that we are certifying to the grade of high-class butter, will naturally demand butter bearing such certificate. The inferior butters will therefore be at a great disadvantage. At present they are not at such a disadvantage, for the reason that neither the inferior nor the best butter bears any distinctive label or anything to guarantee that one is inferior and the other high grade.

UNIFORM QUALITY OF DANISH BUTTER.

Q. All the Danish butter is labeled in the London market?—A. All the Danish butter that is exported is of a certain grade, a high-grade butter. It is called Danish butter; it is purchased in England simply as Danish butter. The English buyer merely orders so many pounds or casks of Danish butter, and that is the extent of the contract. He pays the price quoted in the market on the day of his purchase.

PRICES OF BUTTER IN ENGLAND.

Q. Are you aware that there is a very wide difference in the price of butters, between the high-grade British and Danish and the ordinary American and Canadian?—A. There is a difference of 3 or 4 cents a pound.

Q. Do you mean pennies or cents?—A. I mean cents; I am quoting in United States money. There is a difference of 3 or 4 cents a pound. The import price in England of Danish butter in 1899 was 23 cents a pound. That was the average import price of all the Danish butter sent into the United Kingdom during the calendar year 1899.

Q. That is what is called 11 pence half-penny a pound, British figures?—A. The price averaged 22.95 cents for the entire year, but the quotation would naturally vary somewhat from day to day.

For the same year, the calendar year 1899, the butter imported into the United Kingdom from the United States averaged 19.2 cents per pound, and the Canadian butter imported into the United Kingdom averaged 19.4 cents per pound. In that year the Canadian brought a trifle more than the United States butter; but you see there is a

difference of nearly 4 cents between the price of the Danish and the United States and Canadian butter.

Q. Is it not also a fact that the Danish butter holds its price in the market almost against any changes, and it is a very high price, while there are fluctuations in the butter that comes from the United States and Canada?—A. The Danish butter is noted because of its uniformity; the high price is uniformly maintained. I do not mean to say that the same price is maintained, but I mean to say that Danish butter has a high price always, as compared with the price of other butter. The Danish butter brings the highest price of any butter imported into the United Kingdom, except the fresh butter. The fresh butter that comes in from Normandy brings a higher price, of course, but that is a peculiar trade. The Normandy butter comes in within twenty-four hours from the churn, and is perfectly fresh. It is unsalted, while the Danish butter, like the other imported butters, is a salted butter.

EXPORTS OF CHEESE FROM THE UNITED STATES AND FROM CANADA.

Q. (By Mr. A. L. HARRIS.) Do the same conditions exist in regard to cheese, substantially, that you have described in regard to butter?—A. In our exportation of cheese we have had practically the same experience as that described for our butter export trade. In 1881 our exports of cheese reached the highest figures ever attained, amounting to 147,996,000 pounds, having a value of $16,380,000. From that time the exports declined. In 1890 they had fallen to 95,376,000 pounds, valued at $8,591,000; and in 1899 they amounted to only 38,199,000 pounds, valued at $3,316,000. During the past twenty years there was a loss of over 100,000,000 pounds in our export trade in cheese, and the reason for this was essentially the same as that given for the decline in our exportation of butter, namely, the shipment of an inferior product, chiefly the shipment in large quantities of so-called filled cheese. Soon after 1880 it became the practice to export filled cheese. This adulterated product was sent abroad in the guise of first-class or full-cream cheese. The result was that the British purchaser very soon discovered that he was being defrauded. The inferior quality of the filled cheese soon became known in the British market and our trade began to fall off. Our export trade in cheese was lost to Canada, where measures were taken to prevent such an experience. The Canadian government not only prevented the manufacture of filled cheese, but took measures to improve the quality of the Canadian product and to secure its ready sale in the British market. They saw an opportunity to establish a trade when that of the United States began to fall off, and they made the most of it, as is shown in a striking manner by their export figures. In 1880 Canada shipped abroad 40,369,000 pounds of cheese, valued at $3,893,000. In 1890 the trade had increased to 94,260,000 pounds, having a value of $9,372,000.

During the past year, 1899, the exports of cheese from Canada reached the enormous total of 189,828,000 pounds, having a value of $16,777,000. In the space of twenty years the Canadians increased their shipments from about 40,000,000 to nearly 190,000,000 pounds.

CAUSE OF INCREASE OF CANADIAN CHEESE EXPORTS.

Q. How do you account for that enormous increase on the part of the Canadian export of cheese?—A. That increase is accounted for very largely by measures taken by the Canadian government to develop the cheese industry and to establish an export trade. The Canadian government began by helping the manufacturers. It gave liberal bonuses for the building of factories and, under the supervision of the ministry of agriculture, established a system of instruction and inspection that brought about a rapid improvement in the methods of cheese production. As the surplus above domestic requirements increased, the government took measures to place that surplus in the foreign market by securing for the exporters favorable transportation facilities. And while I am discussing what has been done by the Canadian government for the cheese export trade, I wish to include also the export trade in butter, because the measures taken by Canada for the shipment of butter and cheese naturally go hand in hand.

INSPECTION OF CHEESE FOR EXPORT.

Q. There is a possibility, then, of having a system of inspection that would insure a pure cheese?—A. The inspection system that I spoke of would be particularly valuable in the case of cheese, for the reason that no filled cheese would go out as honest cheese under the Government certificate. The probability is that after the system of inspection had become introduced the filled cheese exported would be at such a great disadvantage without a certificate that it could not maintain its market as it does now.

Q. Would this inspection be at the factory?—A. The inspection would probably be in part at the factory, just as the meat inspection is in part at the packing house.

DEVELOPMENT OF BUTTER EXPORTS BY CANADA.

I said that the Canadian government has assisted in the establishment of cheese factories by giving liberal bonuses, and I can also say that it has done the same as regards the manufacture of butter. It has not only done that, but it has established a system of cold-storage transportation from the factory or the creamery to the foreign market. The measures for the development of the butter export trade began to be taken in 1895, I think. The Canadian government offered a bonus of $100 to creameries that should install and maintain cold-storage facilities in connection with their creameries. This $100 was to be

paid during a period of three years, $50 the first year, $25 the second, and $25 the third. The government also secured cold-storage facilities upon railroads, so that the butter after being cooled at the creamery would go directly into a refrigerator car for safe transportation to the point of ocean shipment. At the terminal of the railroad the government established a cold-storage warehouse in order that the butter could be safely kept between the time of reaching the railway terminal and the loading upon the ship. The government also secured refrigeration service on steamship lines to the British ports. This cold-storage system was installed according to instructions prepared by the department of agriculture, and, in some cases at least, Parliament defrayed the expense of installation. To give the trade a start, the government contracted with the steamship companies for cold-storage space, put in the necessary refrigerator chambers, and then guaranteed to the steamship company the full freight charges for the service. Under these conditions very favorable transportation rates were procured, and as the initial expense was borne partly by the government, it was possible for the Canadian producers to send their dairy products to the British market at very low rates. In this manner a great inducement to exportation was offered.

The government also watched very carefully the quality of the product shipped, issued instructions as to methods of packing, branding, labeling, etc., and, in fact, practically supervised the entire exportation. Numerous trial shipments were also made by the government, the government purchasing the produce and sending it over and disposing of it through its own agents abroad. I might mention, too, that other than dairy products were shipped experimentally. Canadian fruits, for instance, were sent abroad in trial shipments.

EXPERIMENTAL SHIPMENTS OF BUTTER.

Q. (By Mr. KENNEDY.) Is it your belief that if America is to compete with Canada for this trade in foreign markets we must copy the methods of the Canadian government?—A. I do not think that it will be necessary for us to do what the Canadian government has done as a whole. The Canadian government has gone pretty far in the matter. I believe that if the trade can once be given a fair start and the American producer convinced that there is a profit in it the facilities will be forthcoming. The producers themselves will take the necessary action to get the required transportation facilities. But first of all it is important—it is necessary—to show that there is a possibility of establishing such a trade on a profitable basis. The initial experiments can very properly be made by the Government; and, in fact, they are, in a small way, now being inaugurated. The United States Department of Agriculture, by direction of Secretary Wilson, has been making experimental shipments of butter during the last two or

three years, and with considerable success. We began, in 1897, to send high-grade American butter in small lots to the British market. The Department purchased this butter from leading creameries in several States. In 1897, lots were procured from eleven different States, I believe, such creameries being chosen as had made a favorable reputation for their butter. Under directions from the Department, this butter was put up in the form thought to be best suited to the requirements of the British market, not only as regards quality but as regards packing. The butter preferred in the British market is a mild butter, lighter than ours in color, and with less salt, and the butter sent abroad was so made. It was packed in a variety of packages, experimentally, in order to ascertain, as far as possible, what packages would be most desirable for future use. As a result of the experiments in the first year, the Department adopted for subsequent shipments a cubical box similar to the Australian box, but tapering slightly from top to base, in order to facilitate unpacking the butter. Aside from the taper it is identical in size and shape with the standard Australian box that is in such favor in the British market.

Trial exports have been continued during the past year, some of the shipments going to new destinations. Butter has recently been shipped to the Orient to some extent. Experimental shipments were first sent to London, then to other English cities, and later to Paris. It is, of course, only the beginning of experimentation in this line, but I think I can say that the result has been on the whole highly satisfactory. We have convinced the British butter merchants, to some extent at least, that a high grade of butter can be made in the United States, butter that is equal to the best butters imported from other countries. That, of course, was the chief object of the experiment—to show the British consumer that all American butter was not inferior, but that, on the contrary, we were making here a first-class article. These experimental shipments of butter will probably be extended, and further beneficial results are hoped for.

ARTIFICIAL BUTTER IN EUROPE.

Q. I infer from what you said the other day about the large shipments to the Netherlands of certain ingredients which entered into the manufacture and composition of imitation butter that there must be a large manufacture of imitation butter at certain points in Europe. Can you say where that imitation butter finds a market?—A. The manufacture of oleomargarine, or artificial butter, is carried on most extensively in the Netherlands. The exports from the Netherlands exceed 100,000,000 pounds a year. Of these exports by far the largest part goes to the United Kingdom, while the remainder is distributed quite generally over Europe and also to some extent through tropical countries.

EXTENT OF BRITISH DEMAND FOR BUTTER.

Q. So that there is a demand for that artificial butter in Europe?—A. Artificial butter is used now quite extensively in Europe. It is probably used most extensively in England and Germany, but, although the manufacture of artificial butter has increased very largely, the consumption of real butter has also increased. There is a more general use of butter throughout the world. The poorer classes of the people are beginning to use it much more than formerly, and for that reason the production of oleomargarine has not destroyed the market for butter. The United Kingdom, of course, is the important butter market of the world, and to show you what has been the increase of the demand in that market I will quote some statistics I have on the subject. In 1886, which is the first year for which we can give separate statistics of the imports of butter into the United Kingdom (prior to that year butter substitutes were grouped with butter, oleomargarine being included in the butter imports as recorded; we can not divide them prior to 1886), the imports of butter into the United Kingdom from all sources amounted to about 173,000,000 pounds. In 1899 the imports of butter into the United Kingdom amounted to about 380,000,000 pounds. Thus in a period of fifteen years the demand of the British market for imported butter more than doubled. Practically each one of the past fifteen years has shown a marked increase in the imports of butter into the United Kingdom. The increasing exports from the various countries that I have mentioned as showing rapid development are chiefly due to this growing demand of the British market. Those countries are supplying this demand—they send their butters to Great Britain almost exclusively. It is the great butter market of the world.

LACK OF COLD-STORAGE FACILITIES.

Q. (By Mr. A. L. HARRIS.) In the experiments in shipping that you are making in the Department, do you find the necessary conditions or facilities for cold storage?—A. There are excellent facilities on the railways of the United States. We have probably the best cold-storage transportation facilities by rail of any country, but there is a lack of sufficient accommodations on the ocean steamships. The cold-storage chambers on the steamships plying between the United States and Europe are very largely monopolized by the meat interests. They are contracted for and controlled by the packers. The meat exporters take measures to procure the amount of space required for their trade and the necessary refrigeration facilities, but aside from that industry there is not sufficient cold-storage service, and it has been found difficult at times in our experimental shipments to get the facilities needed. That is one thing, of course, that would have to be remedied. Another

great difficulty is the lack of cold-storage facilities at the docks. One of the chief dangers in shipping butter and other perishable products is that they will arrive at the port of shipment some time in advance of the sailing time and become damaged during the wait. We need cold-storage facilities at the docks, so that products that are brought on the refrigerator cars can be transferred at once into cold storage, awaiting the time when they can be put aboard ship.

Q. Have you anything further on the subject of dairy products?—A. I should like to say that practically the same measures that have been taken by Canada for the development of an export trade in dairy products and in other perishable products have been taken within the last few years by the Australasian colonies.

Q. Do you think it would be advisable for the Government to give some attention to this question of proper facilities for shipment?—A. I do most assuredly think it would be well for the Government to take some measures. I do not know that it would be best for the Government to provide cold-storage and cold transportation facilities, as Canada has done, but I think that the Government can very well in an advisory capacity make recommendations, and I do think that the Government should, first of all, take into its hands the matter of inspection. I think that is the most important measure to be taken, so as to prevent inferior and fraudulent produce going abroad under false colors, as is now possible.

### EXPORTS OF GRAIN.

Q. You touched the other day upon the subject of the grain export. Have you anything additional to say in regard to conditions favorable or unfavorable for the exportation of grain?—A. Within the last few years many complaints have been made in foreign ports as regards the condition in which some of our grain arrives. The grains that have been complained of chiefly are indian corn, wheat, rye, and barley. Complaints have been made, as regards indian corn, that in many cases that grain has reached the European port in a damaged condition, caused by sweating. It has been claimed that much moldy grain has come into European ports, and not only that, but to some extent it has been claimed that grain of a grade inferior to that of the certificate upon which it was purchased has been received. As a rule, our grain is sold on the certificates of inspection that are furnished by the boards of trade and chambers of commerce at the ports of shipment in the United States. The foreign importer contracts for the grain on the strength of that certificate, and, under the rules adopted by our commercial bodies that inspect, the certificate is conclusive. The importer who has bought a cargo of grain upon the certificate issued by one of our boards of trade practically has no redress if, to his idea, the grain does not correspond to the grade that is certified to by the inspector.

LACK OF UNIFORM INSPECTION.

It may be that there is some carelessness in the inspection of export grain in the United States, but from what attention I have given to the matter I am inclined to think that the complaints based on the ground of fraud are mostly unfounded. Unfortunately, the methods of inspection in vogue in the United States lack uniformity. Each board of trade or chamber of commerce adopts its own rules of inspection and its own regulations for grading. In most cases the grades are changed somewhat from year to year, following the average condition of the crop, but the changes made at the several ports are not always uniform. The result is that the certificates issued at different ports do not always mean exactly the same thing. Suppose, for instance, an importer buys a cargo of corn shipped from Baltimore and certified to be No. 2 mixed corn, sail grade, and then a little later buys a cargo shipped from Galveston, Tex., bearing the same certified grade, and it so happens that owing to different standards of inspection the one cargo differs somewhat in quality from the other. The importer who has received one certified grade and then, under a similar certificate, receives an inferior quality, not understanding the conditions, would naturally feel that the second consignment fell short of the standard called for by its certificate.

Q. Is it possible to fix a standard grade for all the ports of the United States?—A. I believe that it would be possible.

Q. Have any steps been taken in that direction?—A. Not so far as I am aware.

Q. If so fixed, would it not be much to the benefit of the exporter from this country?—A. I believe that it would be. If we could have a uniform system of grading for all ports of shipment, so that this variation could not arise under proper inspection, I think it would be a great advantage to the export trade.

Q. (By Mr. FARQUHAR.) Do not all the boards of trade in the United States endeavor to conform to the Chicago inspection and grade or the New York inspection and grade in those two markets at fixed prices?—A. In a general way, of course, the great ports are followed, but as a matter of fact they are not followed absolutely. Grain inspection is had, of course, at practically all of the ports. A great deal of grain is now shipped from our Southern ports, such as Galveston, New Orleans, and Newport News, and the commercial organizations that control the inspection there establish their own rules of grading, and these rules sometimes differ slightly from those in force at New York and Chicago. We made inquiries recently in regard to that very matter, and from the replies received at the Department it is evident that there is, in a number of cases, an appreciable difference between the grades established in a given year at the several ports.

Q. You are speaking of the changes that occur there in grading.

Do not these changes nearly always—in 90 per cent of the cases—occur through the difference of the character of the crops of the season?—A. Where changes are made they are supposed to be based upon that very thing.

Q. It is not an arbitrary thing on the part of the inspector of the board of trade at all, but it is simply that the very grain that comes out of the very section in one year will be graded possibly below or above what it was the year before?—A. Exactly. The grades are based, of course, on the average crop; but the changes in the average crop are not followed as carefully in some ports as in others. We had replies from some ports indicating that the grades established there remain practically the same from year to year.

Q. They do on winter wheat, for instance; they hardly ever change. But will you not find always a great many changes there in the spring wheat because the climatic changes are so much different?—A. The changes in grading are most noticeable in corn, of course. I do not think that the changes in wheat are so marked as the changes in corn. It has been chiefly the corn against which these complaints have been made on the ground of grading.

INSPECTION CERTIFICATE.

You spoke of the official certification.[1] Now, that is another matter that I am glad you have suggested, for it has caused a great deal of misapprehension abroad. The certificates issued by our boards of trade and chambers of commerce usually bear the inscription, "Official inspection certificate." The importers abroad quite generally understand that to mean official as applying to the Government. I find abroad a general impression that our certificates are Government certificates.

Q. And yet, practically, they are just as good as Government certificates, are they not?—A. Well, that is a question.

Q. Well, did you ever find a board of trade that did not select the very best men that could be found there as inspectors? Merit and not favoritism rules in every case of that kind, considering the millions of money that are involved in the exchanges and boards of trade.—A. That is a very general question. I am not criticising our inspection system as a whole, because I think it is a remarkably good one under the circumstances, considering the vast extent of the country, the different conditions that prevail in the different sections, and the wide distances between the various ports. I think that on the whole the system is an admirable one.

QUESTION OF GOVERNMENT CONTROL OF INSPECTION.

Q. (By Mr. A. L. HARRIS.) Well, owing to the immense quantities of grain and the immense interests that are involved, would it not be

[1] [The interrogatory preceding this response was omitted from the published report of testimony.]

better to have the Government fix the grades and have some means to protect against frauds in mixing, etc., and in bills of lading, owing to the fact that it is discredited? That is, would it not be more satisfactory both to the shipper and to the commission man to know that the inspector was under the control of the Government?—A. I believe that it would be a great advantage to the trade if some steps were taken to secure uniformity.

Q. (By Mr. FARQUHAR.) Why would it not do for the Government to license these inspectors? That would be the way to regulate it.—A. That would be one way, of course. I do not mean to say that the Government should take the matter entirely into its own hands. I am not prepared to say that that is at present necessary, but I think it might be well to place the inspection under the general supervision of the Government, so that uniform rules could be enforced. To establish an official inspection service for grain at all our ports would be quite an undertaking, and I question the immediate necessity of going so far as that.

Q. Why should it not be done in the case of cereals and everything of that kind just as we have in the Bureau of Animal Industry now in the case of animals, meats, and live cattle? Why is there not just as much necessity to inspect the one as the other, and why is there not just as much necessity for official inspection?—A. I am not prepared to say that it would not be a good thing. I have not reached a conclusion in my own mind as to whether it would be advisable at present for the Government to take over entirely to its own control the inspection of export grain. It is, of course, a very comprehensive system. It might be well for the Government to begin by establishing an official inspection that would be optional with the exporter. Argentina has recently done that very thing. The Argentine Government has established an inspection service for grain at its several ports, so that exporters, by paying a small fee, can have their grain officially inspected and obtain an official certificate as to its grade. The Argentine inspection is entirely optional, and it seems to me that in introducing an official inspection of export grain in the United States it would be best at the outset to make it optional rather than compulsory. I believe the advantages of the Government certificate would soon lead to its being demanded by foreign buyers.

Q. (By Mr. A. L. HARRIS.) Would the shipper or commission man object?—A. There would undoubtedly be considerable opposition to a compulsory official inspection. It is very natural to expect some opposition to such a step by the Government. There would probably be opposition on the part of those very organizations that are now controlling the inspection.

Q. Is it not almost as important as the inspection of meat?—A. I hardly think it would do to say that it is almost as important. No; I do not think that there is such a crying need for Government inspec-

tion as there was in the case of meat. There are not the same sanitary reasons for it.

Q. In other words, complaint has not become so common?—A. It has not, because the present grain-inspection system is already a fairly good one, although far from perfect.

Q. Well, would it not be an assurance to the foreign importer when he buys a cargo to know that the grade is the same without regard to the port from which it was shipped?—A. Undoubtedly.

Q. In other words, is not this the tendency now: If they find that the port at Galveston has a lower grade for low grades that go to that port for shipment, would it not generally have a tendency to discredit the grades of the whole country when they pay little attention to what section of the country the grade is shipped from?—A. It would very naturally do so.

ADVANTAGES OF GOVERNMENT INSPECTION.

Q. (By Mr. FARQUHAR.) Would not the establishment of Government inspection make a uniform grade all over the country—naturally tend to?—A. It should do so.

Q. And would it not give a better price for our cereals in Europe if they had the Government certificate back of them, and not that of an individual nor a corporation nor a board of trade?—A. I think that it would.

Q. (By Mr. A. L. HARRIS.) Even if it did not give a better price it would give satisfaction to the people who are buying it now?—A. I should hesitate slightly on the ground of feasibility just now. To my mind it is a question whether it would not be better to extend the system of compulsory Government inspection more gradually. Take, for instance, the dairy products, and first put that branch of the export trade on a satisfactory basis. In other words, introduce these reforms by degrees.

LACK OF INFORMATION ABOUT INSPECTION CHANGES.

I want to say that of course the representatives in this country of foreign importers of grain are supposed to notify the importers whom they represent of any changes in the grading, and to give them exact information on that point, but it often happens that this is not properly done. The boards of trade themselves do not inform foreign importers of the changes. That is left to the representatives in this country of the importers, and there is often laxity about sending the proper information—at least so I have been informed on the other side.

DAMAGE TO GRAIN DURING VOYAGE.

In speaking of the damaged condition of the grain that arrived in Europe, I did not mean to imply that it was exported in such condition. My own belief is that a very large part of the damage occurs on the

voyage. In other words, I think that in many cases where cargoes are complained of in foreign ports the grain when shipped from the United States was in proper condition.

UNFAIR COMPLAINTS INFREQUENT.

Q. (By Mr. KENNEDY.) We frequently hear of commission merchants informing shippers of produce that their stuff was received in a damaged condition, and that it is done for the purpose of cheating the farmer, the fact being that the produce more often is in excellent condition when received, but reported in a damaged condition. Is it probable that anything of that practice prevails on the other side in regard to our grains?—A. I have no doubt that there are unscrupulous people abroad, as there are all over the world, who will in some cases make unfair complaints of that kind, but I think as a rule that such cases are rare.

CARELESSNESS IN SHIPPING CORN.

Q. Is it more difficult to ship shelled corn than it is to ship wheat in bulk?—A. It is more difficult. The corn gets out of condition more readily than the other grains, because its moisture content is greater. It is in the case of corn that most of the complaints have been made. Sometimes, when corn in otherwise perfect condition is loaded here in hot weather, the heat it has absorbed causes the grain to sweat and become moldy before it reaches the other side, and then the purchaser there naturally wonders whether that corn was in good condition when it was shipped. I believe, as I said before, that it is on the voyage that most of the damage is done. Much of the damage undoubtedly occurs in the case of bulk cargoes carried by tramp steamers. There are comparatively few complaints against corn carried by the regular liners, for as a rule the regular liners give greater attention to ventilation, and in fact to the care of the cargo generally. Ventilation is a very important factor in the shipment of corn. When shippers load corn into a steamer at a Southern port in hot weather, then batten down the hatches and without any ventilation at all attempt to carry that cargo across the ocean, the chances are very strong that under such conditions some sweating will occur.

CORN LOADED IN IRON STEAMERS.

Corn is sometimes loaded into iron steamers without any protection against the heated iron sides. There should be some kind of a protection—either a board sheathing or a protection of bagging—against the iron sides of the steamer, for as she lies in port her sides above the water line naturally become very much heated by the sun, and when the corn is poured in and lies right up against these hot sides it is not strange that the contact with such heat causes it to sweat.

CORN STOWED IN COAL BUNKERS.

Then, too, corn is sometimes loaded into bunkers that are intended primarily for coal. Quite frequently on tramp steamers where they take a full cargo they load corn into one of the coal bunkers, which are, of course, amidships, and adjacent to the boilers. It is in these bunkers that I think much of the damage is done. The heat from the furnaces and boilers during the passage gradually works its way through the bulkhead, and it is not uncommon, where corn has been loaded in a bunker, to find it badly sweated, especially along the side of the bulkhead that separates the bunker from the boiler space. There the corn is often greatly damaged. It is a question whether corn should be loaded in bunkers at all, owing to the great risk that is taken, or at any rate, whether there should not be some conditions attached as regards sheathing and ventilation.

IMPORTANCE OF VENTILATION DURING VOYAGE.

Even in the ordinary holds, remote from the boilers, unless ventilation is had, corn is apt to become heated at the top of the holds, more particularly during hot weather, because of the heat of the sun on the deck. That could undoubtedly be prevented by proper ventilation. The trouble with the tramp steamers is that they frequently go short-handed, and do not have a sufficient force of men to attend to the ventilation properly. It is possible in fair weather to lift the hatches and let air into the holds where the corn is stowed, but that is often neglected. From my investigations I believe that if proper ventilation were provided a great deal of the damage that now results could be avoided. I understand that the steamers plying from Argentine ports carrying Argentine corn to Europe are now very generally equipped with ventilation facilities. That is a long voyage, and they have discovered the importance of ventilation; but it is unquestionably a fact that a great deal of the corn shipped from the United States is not properly attended to en route.

IMPORTANCE OF CLEANING CORN BEFORE SHIPMENT.

There has also been quite a general complaint against our corn abroad on the ground that it is too dirty. The foreigners say that in this regard it does not compare favorably with the corn shipped from other countries. They seem to think we are more careless, and that we take less pains to clean our corn than is the case in some other countries. It can not be denied that the corn frequently has a good deal of dirt in it, such as broken grains, pieces of cob, etc. When this occurs the danger of sweating is very much increased. The dirt fills in the interstices between the grains, thus excluding the air, and under such conditions heating naturally occurs much more readily. If the

corn were cleaned more carefully before being exported there is no doubt that a great deal of loss would be prevented.

A few weeks ago I received a sample of some foreign materials that were discovered in a cargo of corn shipped from the port of Galveston, Tex., to the Free Port of Copenhagen. Mr. C. D. Hage, the director of the Copenhagen Free Port Company, forwarded to me a box containing quite a variety of metallic articles, including spikes, nails, bolts, screws, pieces of wire, foundry drippings, etc., and also other matters such as glass, pebbles, and the like, that were sent over there in a cargo of corn. [Producing photograph.] I had this material photographed, and I will hand you the photograph that you may see. The articles are shown at one-half their natural size.

DANGER TO MILLS FROM TRASH IN CORN.

Q. (By Mr. A. L. HARRIS.) Is there not danger of our grain being discredited the same as butter has been heretofore?—A. Such cases as this, of course, work very materially to the detriment of our export trade. The seriousness of this particular case will be better understood when I say that, supposing that the corn had been cleaned, the company there did not subject it to any screening, and it went out over the Kingdom of Denmark, carrying this material with it, and these nails and spikes, etc., got into the mills. If you will examine that photograph carefully, you will see that some of the spikes have been between the mill rollers and were flattened out. They did great damage to the milling machinery. The millers are holding the company liable for the damages, Mr. Hage writes me.

Q. (By Mr. KENNEDY.) That is taken from one cargo?—A. This was sent to me as a sample of material that was taken from corn sent from Galveston in one cargo. Part of that material was sent in to the company at Copenhagen by the millers.

GRADING OF EXPORT CORN AS REGARDS CLEANNESS.

This case shows that there is undoubtedly some carelessness. The foreign importers claim that the corn shipped as No. 2 sail grade should be much cleaner than a large part of it proves to be. The contract calls for a grain that is reasonably clean, and they naturally hold that that condition is not carried out in a case of this kind.

Q. (By Mr. FARQUHAR.) You do not know what the grade of this corn was when it was shipped?—A. I am sorry to say that in writing to me about the circumstances of this shipment Mr. Hage failed to state the grade that was certified to; but I have inferred that it was No. 2 sail grade, for several reasons: first, because that is the grade that is generally shipped to Copenhagen; and, secondly, because if it had not been supposedly a reasonably clean corn, the company there would probably have put it through their own screening apparatus.

That is, they would not have been justified in sending out an unclean grade of corn to their customers, and they would not have taken the risk of doing so. But I am sorry to say that Mr. Hage did not state that fact specifically in his letter, and I have not had time to ascertain.

SOURCE OF TRASH IN CORN.

It is a question where this foreign matter came from—where it got into the corn. I presume that this corn may have been simply blown without being screened; however, I do not know as to that. Some of this material was probably shoveled up with the corn when it was put into the shellers. Shellers are sometimes stationed out in the open field. The farmers bring up the corn in their wagons and dump it on the ground in piles, and then it is shoveled from the ground into the shellers. Foreign objects of a less size than the cobs readily pass through the shellers, and these objects would remain in the corn unless it were screened. It would appear, also, that the railway cars in which the grain was carried to the port furnished some of the refuse material. The cars are not always properly cleaned before the grain is loaded. The terminal warehouse or elevator may also have been at fault in this regard.

I want to say in reference to this case that affidavits were presented showing that the steamer had been carefully inspected before the cargo was received, as is the custom. The captain of the steamer made affidavit that the holds in which this corn was loaded were carefully inspected and were free from all foreign matter and in proper condition to receive the cargo. He had a certificate to that effect to show that this matter did not get into the cargo from the ship.

SHIPMENTS OF WHEAT, RYE, AND BARLEY.

Q. (By Mr. A. L. HARRIS.) Are you through with what you desired to say on the subject of grain?—A. I spoke also of wheat, rye, and barley. I will just touch upon these.

Against our wheat complaint has been made abroad that it sometimes contains many unsound and burnt grains, more than would be warranted by the certificate of inspection, and also that it is sometimes deficient in weight. Recently a complaint came to the Department from abroad alleging that some wheat had been received that did not come up to the weight called for in the contract by several pounds per bushel. I also have in mind a complaint made some months ago regarding a parcel of wheat that contained garlic to such an extent that it was necessary to reclean the entire lot before it could go into the mills. Some of the grain did get into the mills before it was cleaned, and produced, of course, a very unpleasant kind of flour.

Similarly, one of the complaints against rye imported from the United States is that it too frequently contains oats in considerable

quantities, making it necessary to reclean the rye before it can be milled and made into flour. As the rye is imported for bread purposes, it is important to have it free from oats and other grain.

Our barley has also been complained about in some cases because of its dirty condition. An instance came to our notice where it was claimed that as much as 10 per cent of impurities occurred in a cargo.

According to the testimony of the foreign importers, the complaints made against American barley are mostly of recent origin. Some years ago American barley was held in high favor abroad. It obtained a market in Europe that was formerly controlled by Russia. But the importers say that within the last few years complaints against the condition of our barley have been numerous, greatly endangering our market, and the probability is that unless some measures are taken to secure more care in cleaning export barley much trade will be lost to us.

NEED OF GREATER CARE IN CLEANING GRAIN.

Regarding our grain export trade as a whole, I think I am safe in saying that the greatest obstacle to the maintenance and extension of that trade lies in the fact that our exporters do not always exercise proper care in cleaning the grain before shipment. In view of the increasing competition we are beginning to meet with from other grain-exporting countries, it is highly important that this ground for complaint should be speedily remedied.

MISUNDERSTANDING OF TERM "OFFICIAL."

Before dropping the subject of grain exports, I want to recur again to the matter of the certificates, and to repeat that it seems to me unfortunate that the certificates issued by our boards of trade should be sent out under the title of "official" inspection. [Producing certificate.] The term "official" in this case is undoubtedly misleading, and it is a question whether it would not be a wise thing to prevent further misunderstanding on that ground by prohibiting boards of trade and chambers of commerce from using the appellation "official" on their certificates. It is unquestionably a cause of much misunderstanding abroad.

Q. Do you think it conveys the idea to the foreign importer that it is a Government official inspection?—A. The foreign importer very generally believes that these certificates are issued by the United States Government. I have talked with many importers abroad who were under that impression, and who were surprised to learn that the United States Government was in nowise responsible for the certification of our export grain.

Q. (By Mr. FARQUHAR.) Does not nearly every single purchaser or Liverpool broker have his own agent in the United States here in our markets?—A. Many of the larger importers have their agents here.

Q. Those that are of any account at all?—A. Many of the large importers have their representatives here, but these certificates, of course, pass into the hands of other buyers. The importers, in reselling their imported grain, sometimes base their contracts on the original certificate, and in such cases the secondary buyers have not the same means of ascertaining the real status of the certificate.

Q. The Government inspection would cover all doubts and would verify to the consignee or the factor or the commission merchant or the original purchaser or anyone that there was bona fide inspection here when put on board of vessels, subject, of course, to stand the transportation and delivery?—A. Yes.

IMPORTANCE OF CARE IN LOADING CORN.

Q. (By Mr. A. L. HARRIS.) Do you desire to go any further into grain?—A. One thing occurs to me that I intended to add in connection with the loading of grain. I said that it was a question whether corn ought ever to be loaded in the bunkers, since they were so close to the boilers and therefore so liable to become heated on the voyage. The same objection applies, of course, to the loading of grain in any of the holds that are adjacent to the boiler or engine space. In the distribution of the cargo the corn ought, when possible, to be loaded in holds that are remote from amidships.

Q. Would this trouble be obviated to some extent if the bottoms were controlled by Americans? You spoke a moment ago about the excellent facilities on land.—A. I have no doubt that it would be far easier to control the methods of transportation if we owned the ships. Does that answer your question?

Q. Yes; that is what I wanted.—A. Carelessness sometimes occurs as regards the stowing of grain with other merchandise in the same hold. A case recently came to my attention where a hold was partially filled with corn, and then upon that corn were stowed bales of cotton. Such a condition of affairs, of course, ought not to be permitted. It goes without saying that corn put down in the hold and then covered over completely with bales of cotton is going to sweat and become damaged. I speak of this case to suggest that there is a great deal to be considered in regulating the methods of shipping grain across the ocean.

PACKING OF COTTON FOR EXPORT.

Q. What have you to say in regard to the export of cotton?—A. The principal ground of criticism against American cotton in foreign markets is the poor packing. A great deal of our cotton is still baled in the old way. We ship it in large bales, weighing about 500 pounds, and much of it is put up in inferior baling materials. The damage that thus results is not so apparent in the United States as it is at the

end of the journey across the sea. Our exporters do not seem to realize the conditions that our cotton has to meet in foreign countries. The packing is generally sufficiently strong to carry the cotton safely to the seaboard and to get it aboard ship, but when it comes to be unloaded in the foreign port great loss is apt to result. Under the rough handling to which the bales are subjected in the process of unloading from the ship's holds to the docks, the flimsy baling material becomes badly torn, and usually a large amount of cotton is shredded off and strewn along the docks. Such cotton is practically ruined, becoming waste cotton. The coverings of the bales are generally so badly damaged that before the cotton can be reshipped much patching has to be done, and often entire rebaling. Foreign importers naturally complain of this, because it subjects them to so much additional expense.

An interesting instance came to my attention while in Russia last summer where the insecure packing of American cotton resulted in a great deal of loss by theft. We send considerable quantities of cotton to Russia. Most of it is transshipped for the Baltic at such ports as Liverpool, Bremen, and Copenhagen, although within the last year or two some important consignments have gone direct to Russia without transshipment. The United Steamship Company, of Copenhagen, has been particularly enterprising in its efforts to establish a direct service between the United States and Baltic Russia, and the boats of that company have recently been carrying cotton right through from New York to St. Petersburg. However, the chief part of the American cotton marketed in Russia still goes in the first instance to other European ports, where it has to be transshipped in order to be forwarded up the Baltic. By the time that cotton has been discharged at the Russian ports of Reval and St. Petersburg it is apt to be in very poor condition as regards the baling. From these Baltic ports it has to be sent overland by rail to Moscow, where the Russian manufacture of cotton goods is chiefly carried on. Owing to the numerous rents and tears that occur in the bale coverings because of the poor baling materials, a great deal of cotton is lost before it reaches Moscow. It generally goes there by slow freight, frequently with many stops, and I was informed that the peasants along the route sometimes steal great quantities of this cotton from the trains at night, pulling it from the damaged bales in large shreds, as they can readily do, owing to the insecure packing. In this manner the importers at Moscow have been losing so much of their consignments from America that they are now striving, as far as they can, to replace our cotton with that produced in southern Russia. In the south of Russia they are beginning to grow American cotton quite extensively. Some years ago they secured American seed, and already they have had considerable success in the production of our upland cotton. They take great pains to bale it securely. They use a much smaller bale

than the American, and pack it so tightly and firmly that no cotton can be lost or stolen from the bale. By such methods they are gradually establishing quite a trade at Moscow, to our loss.

I spoke of this case as a rather interesting one, illustrating how a trade can be injured by neglect in providing proper packing materials. Some of our cotton growers, in order to save a few cents on a bale, make it a practice to use the cheapest possible baling materials that will carry their product to the port. While such a short-sighted practice may result in a slight saving at the outset, it is certain in the long run to do great damage to our trade. Other cases similar to that in Russia as regards the poor baling of American cotton have come to my attention abroad, and I think I may say that, generally speaking, our cotton export trade is in this respect fairly open to criticism. It is to be hoped that the more general adoption of the round or cylindrical bale will remedy this obstacle to our export trade in cotton.

I have mentioned the case of cotton especially because this product is decidedly our most important agricultural export, but it does not by any means afford the only instance of this kind. There are many other cases in our export trade where failure to give proper attention to the packing of the product is working to the detriment of the trade.

Q. Then the American producer and the American shipper, you think, suffer to some extent, owing to the imperfect manner in which the goods are sometimes sent from this country?—A. Yes.

Q. And greater care should be taken along these lines?—A. Yes; it is very important.

### QUESTION OF GOVERNMENT AID IN EXTENDING FOREIGN MARKETS.

Q. It is a very general complaint among agricultural producers that little effort is made to secure a foreign market for their products. What do you know about that?—A. I think I may fairly say that, comparatively speaking, little effort has been made in the interests of the United States farmer as regards the exportation of his produce. The manufacturer seems able to accomplish more in this direction; he seems to have facilities for pushing his trade that the farmer has not had, or at least has not taken advantage of. I think it is true that more active measures have been taken to make a market abroad for American manufactures than for the produce of American farms.

Q. (By Mr. KENNEDY.) Is not that very largely because the American manufacturers push for these markets themselves?—A. Exactly. The manufacturer seems to be in closer touch with the foreign market than the farmer. He sends his representatives abroad, establishes his agencies there, and, speaking generally, there seem to be more facilities for the extension of trade in manufactures than there are for upbuilding the agricultural export trade.

Q. Manufacturers do for themselves the work which, if done for

the farmers, must perhaps be done by the Government or some other agency?—A. There is a good deal in that.

Q. (By Mr. A. L. HARRIS.) Is it possible for the farmer, owing to his interests being in the hands of so many, to take up the subject of increasing his exports, like it is for the manufacturers, where large capital is invested under one control and they can send out their agents to look after foreign markets?—A. It is certainly not so easy, and I think the question that you have put discloses the secret of the difference.

NEED OF MORE LIBERAL APPROPRIATIONS FOR DEPARTMENT OF AGRICULTURE.

Q. Have you any suggestions to make along the line of the extension of foreign markets for farm products?—A. I believe, first of all, that in the interest of the farmer the Agricultural Department ought to be provided with more liberal means to develop, as far as may be, by governmental assistance, the agricultural export trade. I do not think that enough attention has hitherto been given by the Government to that side of the farmers' interests. We have not done nearly so much as other agricultural countries have done. I spoke of the measures taken by the Canadian government. The appropriation that enabled the department of agriculture for the Dominion to inaugurate the measures I described amounted to $100,000, which was certainly quite a liberal appropriation. The fund that was placed at the disposal of our own Agricultural Department to make experimental shipments of dairy and other agricultural produce was only $25,000. The Australian colonies, like Canada, have also been liberal in appropriating funds to assist the farmer in finding a profitable foreign market for his produce. I feel that much more could be done for the farmers of the United States than has thus far been possible with the scanty means placed at the disposal of our Department for such work.

USEFULNESS OF SPECIAL AGENTS ABROAD.

I believe in the plan of sending abroad special agents, at Government expense, to study foreign markets. I think we should have a goodly number of agents abroad, working solely in the interest of our farm products. These agricultural countries I have mentioned all maintain such agents, not only for the purpose of studying foreign markets and the opportunities they afford for increased trade, but also for the purpose of studying the export methods of other countries. Canada sent her agents to Denmark—the Australasian colonies did the same—to gather information there as to the best methods of shipping dairy and other farm produce. Now that Canada is beginning to compete somewhat with Denmark, especially now that Canada is beginning to cut into the Danish bacon market in England, the Danes are sending agents to Canada to see if there is anything in the Cana-

dian methods of production and exportation that would be an improvement over their own.

SPECIAL AGENTS AS COMPARED WITH CONSULAR SERVICE.

Q. (By Mr. FARQUHAR.) Can not the diplomatic and consular service do the whole thing properly?—A. With certain modifications of the diplomatic and consular service I think undoubtedly most of the objects could be attained, but I do not think it possible as the service is now constituted. I do not believe the consular officers can render the same kind of service that could be had from traveling agents.

Q. You mean the paid agents of the Department?—A. Paid agents of the Department, sent from the Department, if possible. We have tried the consular service, and it has not been altogether satisfactory for this purpose. In the first place, a consul is obliged to remain practically all the time at his place of business—at Hamburg, or Bremen, or some other city, as the case may be—and while he can watch in a general way the trade at a single port, he has to remain right there in order to attend to the routine duties of the consular office. Unfortunately, the course of trade can not be satisfactorily investigated by a man confined to a single place. In order to get a fair idea, for instance, of the butter export trade of Denmark, it would be necessary to travel over that country, to go from the creamery to the terminal warehouse at the port, and, in fact, it would be advisable to leave the port and accompany the butter on the steamer to its place of destination. This is the plan followed by these other agricultural countries that are sending out agents. The agents are instructed to begin at the beginning and to trace the trade to its final destination, in order to gain an accurate knowledge of all its conditions. The consular officers are necessarily engrossed a good deal of the time with the routine of the consular business. As a matter of fact, they can not always take the time necessary to make a thorough investigation of special inquiries sent to them. Furthermore, a consul is appointed to represent the United States trade interests as a whole, and when the Department of Agriculture, through the State Department, as is necessary, sends to him for certain information about a particular feature of the agricultural export trade, that consul may have on file in his office, and probably has, a number of requests from other sources that take precedence, and so the Department of Agriculture has to wait. The consul's attention is necessarily divided. He is not working in the interest of agriculture any more than he is in the interest of other industries, and that, of course, is a great objection from our point of view. It is very important for us to have men abroad whom we can direct and who can work under the Department's supervision. That is the reason why I feel that we never can expect from the consular service, no matter how much it may be improved, such results as other countries are getting from

the employment of agricultural experts working in foreign countries. I believe that the employment of special agents of the Department abroad is the most feasible way of getting the information we want. By placing the right kind of men in competing countries and in countries that afford us most of our markets, we can undoubtedly gather information that will be of great value in extending our trade.

AGRICULTURAL ATTACHÉS AT EMBASSIES.

To supplement the work that can be expected from these special agents, I am in favor of appointing agricultural attachés to our embassies in certain of the most important countries. I am in favor of that plan because of our experience in one case, that of Dr. Stiles, who was stationed at Berlin as an agricultural attaché. Although nominally a diplomatic official, and having from the State Department an appointment as such, he was paid by the Department of Agriculture and was under the direction of our Department. His work was of great advantage to the Department. He traveled about over Europe, as occasion seemed to demand, following the instructions of the Department, in order to investigate matters affecting our agricultural export trade, and in this capacity he rendered, on the whole, a most valuable service. His appointment was, of course, something of an experiment, but I think that it was eminently successful. It is my belief that a few such agricultural attachés, having a diplomatic status, could be of great service abroad to our agricultural interests. Their diplomatic status would give them certain advantages over other agents.

Q. (By Mr. A. L. HARRIS.) They would be very valuable in studying the wants and tastes of foreign people also, so as to learn the proper preparation of our agricultural products for export, would they not?—A. That is, of course, at the base of our export trade. First of all, we must put up a product that will be acceptable in the market to which it is sent. It is of the highest importance to study the peculiar tastes and requirements of the various foreign markets in order that we may know what kind of a product to prepare for export.

ADDITIONAL EXAMPLES OF EXPORT MEASURES TAKEN BY FOREIGN COUNTRIES.

EXPORTS OF BACON FROM DENMARK.

I spoke of the Canadian bacon trade competing somewhat with the Danish bacon trade. The Danes have been preeminently successful in meeting the requirements of foreign markets, and especially of their great foreign market, the British market. Soon after the Danes had placed their export trade in butter on a sure footing they began to reach out after a market for bacon in Great Britain. They studied the wants of that market and they produced a bacon that met those

wants. In 1880 they exported about 13,000,000 pounds of pork, chiefly bacon. In 1890 they exported 65,000,000 pounds. In 1898, the last year for which we have their figures, they exported 135,000,000 pounds, sending most of it to Great Britain. In less than twenty years they developed a trade that now amounts in value to about $15,000,000. They did so, as I said, by studying the requirements of the British market and meeting those requirements.

EXPORTS OF BACON FROM CANADA.

Q. Are there any other countries becoming competitors of American products along the line of studying the wants and tastes and methods of supplying those wants or tastes?—A. As the Canadian people followed the Danes in their methods of exporting butter, so they have followed them in regard to the bacon export trade—the two products naturally go hand in hand. Canada took the same measures that Denmark had taken to get at the requirements of Great Britain in that product, and the result is shown by the Canadian export figures. In 1890 Canada shipped of bacon about 7,000,000 pounds, chiefly to Great Britain. In 1899, within a decade, the Canadian exports amounted to nearly 112,000,000 pounds.

EXPORTS OF BACON FROM THE UNITED STATES.

Our own exports of bacon, of course, are enormous, but they do not show any such growth as I have just exhibited for Denmark and Canada. In fact, there seems to be danger of a decline in our export trade in bacon. We are beginning to feel seriously the competition of these other exporting countries. The first year for which our shipments of bacon were separately reported is 1881. In that year we exported 673,000,000 pounds of bacon, valued at about $54,000,000. In 1890 we exported 532,000,000 pounds, valued at about $39,000,000. In 1895 we exported only 453,000,000 pounds, valued at about $38,000,000. Last year, 1899, we exported 563,000,000 pounds, worth about $42,000,000. While our exports for 1899 were larger than those for 1890 and 1895, you will see that they were considerably smaller than our exports in 1881, which was about the time when the bacon shipments from these other countries were beginning to become prominent. Taking the record of 1899, we find that we sent abroad in that year over 100,000,000 pounds less than in 1881, about twenty years ago. It is a question whether in the years to come we shall not feel still more seriously the competition of such countries as Denmark and Canada, and also the Australasian colonies that are now beginning to ship bacon to England, unless we take some measures to adapt our product more closely to the requirements of the British market.

KIND OF BACON PREFERRED IN ENGLAND.

The bacon preferred by the British nation is what is known as the Wiltshire bacon. It is different from our bacon in being much leaner and firmer. The objection to our bacon is that it is too fat, being a corn-fed bacon. It does not bring as high a price.

Q. They prefer a streak of lean and a streak of fat, instead of all fat?—A. They like a leaner bacon than ours. The Tamworth and Yorkshire swine seem to be the preferred breeds for producing bacon for the British market.

Q. (By Mr. FARQUHAR.) Is not one of the reasons that we fatten our hogs too fast, and that makes a fatter meat?—A. Yes, they are too fat; that is the chief objection.

PRICES OF BACON IN ENGLAND.

I was about to quote the import prices in England of the bacon received from the United States, from Canada, and from Denmark. In 1899 the average annual price of the bacon imported into the United Kingdom from the United States was about 7 cents a pound, the exact quotation being 6.96 cents. The average price of the bacon imported from Canada was 7.3 cents a pound. The average price of the bacon imported from Denmark was 10.6 cents per pound. In other words, there was a difference during 1899 of about 3½ cents per pound in favor of the Danish pork over ours, which is very significant. When you consider the fact that we exported last year 563,000,000 pounds of bacon, most of which went to Great Britain, you can readily see that even a slight enhancement in the price would have meant an enormous gain to the American farmer. If the importance of this matter could be brought home to producers in the United States, so as to lead them to change their methods of production by selecting only the preferred bacon breeds and feeding the kind of rations that will produce the bacon most highly favored abroad, it would be a most profitable lesson, I am sure, for the farming community.

The case of bacon illustrates in a very striking manner, I think, the point that you just suggested about the importance of ascertaining and meeting the exact requirements of foreign markets.

METHODS ADOPTED BY AUSTRALASIAN COLONIES.

Q. (By Mr. A. L. HARRIS.) I believe you have covered all the points that I have down here, Professor, together with suggestions as to the possibilities of the extension of our markets, and I do not know but so far as additional legislation is concerned. If you have anything further, however, to suggest in regard to any remedy for the grievances that you have mentioned, the commission will be glad to hear you.—A. I spoke quite fully of what Canada had been doing, and referred

in a general way to what the Australasian colonies had attempted as regards governmental control of and aid to the agricultural export trade. I should like to mention a plan that has been adopted by New South Wales, one of the most progressive of the Australasian colonies, in the interest of the export trade. In 1895 the government of that colony appointed an export board, so called—"Board for Exports" was the official title, I believe—to take under consideration plans for the development of a larger export trade in the products of the colony. The method pursued by the board was, at the outset, to hold conferences with leading representatives of the various agricultural interests, such as the dairying industry, the meat exporters, the grain shippers, etc. The leading producers and shippers of the various export commodities were called into consultation by the board and their opinions solicited as to the best measures to be taken to assist their particular branches of the trade. As a result of these conferences a great deal of valuable and practical information was elicited, and the board, on the strength of what it had thus learned, made certain recommendations to the government, which were afterwards carried out.

*Government aid and control.*—In a general way the measures adopted in Australasia correspond rather closely to what has been done in Denmark and in Canada; but, if anything, the Australasian colonies have gone even farther than those countries in the direction of government aid and control. New South Wales and Victoria, I think, were the prime movers in the project to assist the export trade of Australasia by State intervention, but the other colonies have been quick to see the advantages of such a movement, and they are now adopting similar provisions.

*Better transportation and terminal facilities.*—One of the first things done by the Australasian colonies to facilitate their export trade was the securing of better transportation facilities by rail from the farming districts to the ports of shipment. Cold storage on the trains was procured, as it had been in Canada, and cold-storage warehouses were established at the ports of shipment where products could be safely kept until the time of sailing. Arrangements were also made with the steamship companies to provide regular sailings from the ports to the British market and to furnish refrigeration facilities on board. Another method taken by the Australasian colonies was the establishment of cold-storage depots and warehouses at London and other British ports. Several of the colonies have depots there for their products, under the management and control of government agents, who receive the produce as it comes from the ship, keep it in cold storage when necessary, and take measures for its proper disposal in the market. The establishment of these terminal depots has undoubtedly rendered great assistance to the Australasian export trade.

*Special agents abroad to study methods.*—The colonies of Australasia

have also adopted the policy of sending agents to study the methods of other exporting countries. Their agents have come to the United States to study our methods; they have gone to Canada to study the methods there; they have visited Denmark and other countries for the same purpose—and in each instance have reported to their own governments the results of their investigations. These colonial governments have taken pains to study the methods of other countries in order to follow them, as far as it seemed wise, in developing their own trade.

*Prizes for best results.*—The Australasian colonies have also adopted one of the most important plans inaugurated by Denmark, namely, that of offering prizes for products put up in the best shape for export. The government furnishes the producers with careful instructions as to the kind of product, style of packing, marking, labeling, etc., desired for the export trade, and under these conditions, at stated intervals, contests are held, at which liberal prizes are offered for the products that best fill the requirements. This plan of offering prizes for superior export produce, and thus furnishing an immediate incentive to the producer, was a very important factor, it is said, in bringing the export butter, bacon, etc., of Denmark up to a high standard, and the official reports from the Australasian colonies indicate that it has also been an important factor there.

### ADULTERATION OF EXPORT PRODUCE.

Q. (By Mr. KENNEDY.) Do you believe that the adulteration of manufactured products in America is ruining the foreign markets for those products, and that these people that you speak about seeing abroad are thus taking advantage of it to gain those markets with pure-food products?—A. Wherever we are losing trade on the ground you mention, these other exporting countries are unquestionably taking advantage of the fact. When the inferior quality of one of our products causes it to find a less ready sale in a foreign market, our competitors are quick to grasp the opening thus afforded; there is no doubt of that.

### RECENT GROWTH OF COMPETITION.

And, generally speaking, I wish to say that the question of competition in regard to our agricultural exports has only of late been assuming such great importance. It has become a more vital question within the last few years because of these very measures that are being taken by competing countries to gain and control the foreign markets upon which we have hitherto depended. The measures that I have mentioned are all comparatively recent. Foreign countries have been doing more within the last decade than ever before in the way of pushing by governmental assistance the exports of their agricultural products. It is therefore important for us to take more active meas-

ures as regards our own exports if we do not wish to fall behind. The figures that I have quoted as to the exports of butter from Denmark, Australasia, and Canada, the exports of cheese from Canada, and of bacon from Denmark and Canada, are, to my mind, very significant, and should serve as a warning to our own producers who depend upon the foreign market.

TIME FOR MORE ACTIVE GOVERNMENT ATTENTION.

Q. (By Mr. A. L. HARRIS.) You think the time is coming, if not here, that the Government may well take some steps in the way of extending and holding our markets?—A. I do, most assuredly. I think it is time for the Government to give the subject more active attention.

VALUE OF CONSULAR AND DIPLOMATIC AID.

Q. Have you anything additional that you care to suggest?—A. There is one thing further that I should like to say to the committee before closing. I do not wish to be misunderstood about my reference to the consular service. I do not want to underestimate the value of the services that the consular corps can render and does render. There is no question that the consular service as at present constituted is supplying a great deal of valuable information to our exporters. I think that the services of the consuls are, as a rule, decidedly valuable, but I have been impressed with the importance of adopting some additional measures, such as are taken by the countries with which we have to compete. I am in favor of sending out as foreign agents men specially qualified to acquire information regarding the agricultural export trade. I believe that experts along that line can add greatly to the service we are receiving at the hands of the consular officials. There are also some special advantages to be gained by having a few representatives in the diplomatic service—representatives solely of the agricultural interests. There are several cases, as you know, where agricultural attachés have been appointed by other nations. One case is that of Baron Herman, here in Washington, who was appointed by the German Government as an agricultural attaché to its embassy in the United States. His expert knowledge of agricultural matters makes him remarkably well qualified for the position, and he is undoubtedly rendering most valuable services to the German Government. Only a few days ago Baron Herman called at my office to present a similar attaché who had just been appointed by the Austro-Hungarian Government as an agricultural expert at Washington. Foreign agriculturists recognize the advantage of having, in addition to the consular service, special representatives abroad working solely for the agricultural interests, and I feel that it is important for us to adopt the same advantageous measures. We should avail ourselves of equal facilities or better.

### VALUE OF AMERICAN AGRICULTURAL EXHIBITS ABROAD.

There is another thought that has just occurred to me. It is that a great deal can be done for our export trade through the medium of the various expositions that are held periodically all over the world. I believe that it would be profitable for the Government to take even greater measures than it has in the past to have at all such expositions an ample display of our agricultural products.

### CONCLUSION.

In answering the interrogatories of the committee, I have not pretended to mention all the measures that might be thought of to extend our agricultural export trade. I have simply endeavored to touch upon what appeared to be the most important features of the subject as suggested by your questions.

(Testimony closed.)

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U. S. DEPARTMENT OF AGRICULTURE.

Report No. 68.

# CATALASE,

## A NEW ENZYM OF GENERAL OCCURRENCE,

### WITH SPECIAL REFERENCE TO THE TOBACCO PLANT.

BY

OSCAR LOEW,

*Division of Vegetable Physiology and Pathology,*
*Detailed to the Division of Soils.*

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1901.

GIFT OF
ESTATE OF
HEINRICH HASSELBRING
OCT 18 '34

# LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF SOILS,
*Washington, D. C., September 28, 1900.*

SIR: I have the honor to transmit herewith a manuscript on a new enzym occurring in the tobacco plant, and probably having much to do with the fermentation and, possibly, with the development of flavor and aroma in tobacco. It represents work done in cooperation with the Division of Vegetable Physiology and Pathology of this Department.

Respectfully,

MILTON WHITNEY,
*Chief of Division.*

Hon. JAMES WILSON,
*Secretary of Agriculture.*

# LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY,
*Washington, D. C., September 28, 1900.*

DEAR SIR: In continuation of the cooperative work of this Division and the Division of Soils, I hand you herewith a paper prepared by Dr. Oscar Loew, on catalase, a new enzym of general occurrence, with special reference to the tobacco plant. The paper is the result of investigations carried on in connection with the tobacco work in your charge.

I regret very much to state that this will be the last of the series of important papers by Dr. Loew which will be brought out in cooperation with your Division, as he has just accepted a position in the Imperial University at Tokyo, Japan.

Respectfully,

B. T. GALLOWAY,
*Chief of Division.*

Prof. MILTON WHITNEY,
*Chief Division of Soils,*
*In charge of Tobacco Investigations.*

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# CATALASE, A NEW ENZYM OF GENERAL OCCURRENCE, WITH SPECIAL REFERENCE TO THE TOBACCO PLANT.

## HISTORICAL NOTES.

That extracts of various vegetable and animal tissues are capable of decomposing hydrogen peroxid with the evolution of oxygen was first observed by Schoenbein.[1] He ascribed the phenomenon to the various soluble ferments (enzyms) occurring in the organisms. The property of producing a blue coloration with tincture of guaiac in the presence of hydrogen peroxid was also ascribed by him to these ferments. He observed both of these reactions with wheat flour, malted and unmalted barley, almonds, mustard, potatoes, and various roots; frequently also with the juices of leaves, stems, flowers, and fungi. He mentions as a remarkable exception that the two reactions fail to accompany each other in beer yeast, since this yeast decomposes hydrogen peroxid but does not give the blue reaction with guaiac and hydrogen peroxid.[2] Among animal objects he obtained both reactions with saliva, secretions of the mucous membrane, the stomach, and the blood. Schoenbein endeavored to explain the blue guaiac reaction by the assumption that the soluble ferments are capable of transforming oxygen into ozone; but neither this assumption nor the assertion that the soluble ferments in general give a blue guaiac reaction in the presence of hydrogen peroxid has been found to be correct. Investigations of recent years have shown that the blue guaiac reaction is due to a separate enzym belonging to the new group of the oxidases.[3] Sufficiently purified diastase, for instance, does not show this blue reaction, but less purified diastase very frequently does. This is not surprising, since various enzyms frequently accompany one another in the cells and show a similar behavior toward solvents. A mixture of enzyms is therefore frequently obtained in the attempt to separate a single enzym.

[1] Journ. für prakt. Chem., vol. 89 (1863).

[2] A sample of yeast, however, examined by the writer, gave a faint blue reaction.

[3] The blue guaiac reaction, obtained in certain cases with and in other cases without the addition of hydrogen peroxid, was observed by Thénard and Blanche and Taddei before the observation was made by Schoenbein. Schoenbein mentions that pure mercury and the noble metals also produce the blue reaction without the aid of hydrogen peroxid.

As to the other property mentioned above—that of decomposing hydrogen peroxid—it is at the present day still generally ascribed to the various soluble ferments or enzyms; but the writer will show in the following discussion that this reaction also is due to a separate enzym of general occurrence. No other enzym but this particular one shows this behavior toward hydrogen peroxid.

Before entering upon a description of this enzym, however, the literature in regard to this subject should be reviewed. Flügge mentions, in his recent work on the micro-organisms,[1] that the property of decomposing hydrogen peroxid is characteristic of all enzyms. Epstein,[2] and Babcock and Russell[3] adopt the same view.

The first to dissent from this generally accepted opinion was P. Bergengrün,[4] who found that the fibrin ferment does not show the property of decomposing hydrogen, but, on the contrary, is destroyed by it. He was inclined to ascribe the catalytic property to the living protoplasm itself, but he did not take into consideration the fact that in some of his experiments he had killed the protoplasm before he made the addition of hydrogen peroxid. He tested blood, leucocytes, crushed spleen, the expressed juice of lymphatic glands, and also yeast cells, and infusoria. The infusoria rapidly died, with a granular disorganization, while their bodies became covered over with fine bubbles of oxygen gas. He found that the power of decomposing hydrogen peroxid varied very much with different objects, and that even the blood of different animals varied in activity. The blood of cattle acts more powerfully than that of horses, and the blood of horses acts more powerfully than that of dogs. In all cases, however, the activity is sooner or later lost. He further observed that it is not the hæmoglobin of the red blood corpuscles which has this activity, as some authors had supposed, but that it is the stroma of these corpuscles with which this activity is connected. Alexander Schmidt had previously observed that the better the hæmoglobin is purified the more it loses its property of decomposing hydrogen peroxid.[5]

In 1892 Jacobson studied this reaction further.[6] He noted that pepsin, ptyalin, and myrosin yield only small quantities of oxygen in

[1] Flügge, Die Micro-organismen, Vol. I, p. 213.

[2] Arch. Hyg., vol. 36, p. 140.

[3] Centralbl. f. Bakt., II Abt., vol. 6, p. 19.

[4] Ueber die Wechselwirkung zwischen Wasserstoffsuperoxyd und verschiedenen Protoplasma-Formen. Dorpat, 1888.

[5] Bergengrün, in discussing Schoenbein's observations, mentions that Schoenbein applied only highly diluted and acid solutions of hydrogen peroxid in his experiments, since he prepared them by rather primitive methods, which explains some discrepancies in the observations of the two authors.

[6] Zeitschrift für physiol. Chem., vol. 16, p. 340. Untersuchungen über lösliche Fermente. Various statements of Jacobson's as to an apparently different behavior of the "catalytic power" in pancreas extract and in almond emulsion may now be explained by differences in the amount of soluble and insoluble catalase (see below.)

contact with hydrogen peroxid, while cold prepared extracts of malt, of almonds, and of the pancreas gland yield a very intense development, which he ascribed to the action of diastase, emulsin, and pancreatin, respectively. He made the interesting observation that this peculiar power could be destroyed by heating to a certain temperature, by "exhaustion of the catalytic power" of decomposing hydrogen peroxid, and by dilute solutions of acids and various poisons, without injuring or destroying the main and characteristic fermentative activity. It seems strange that he did not draw the further inference that the agency which decomposed the hydrogen peroxid might be something else than the known enzyms. It would seem, a priori, very improbable that diastase, for example, could be so changed by hydrogen peroxid as to lose one activity without also losing its other chief characteristics—in short, that it could lose the power of decomposing hydrogen peroxid without also losing the power of transforming starch into maltose and dextrin.

The next author to treat of this question was W. Spitzer,[1] who expressed the opinion that the power of the blood to destroy small amounts of glucose is accompanied by the power of decomposing hydrogen peroxid. But while in 1895 he still ascribed the power of decomposing hydrogen peroxid in general to various other enzyms, in a later article[2] he ascribes this power to one enzym only, namely, to that oxidizing enzym which gives a blue reaction with guaiac tincture in the presence of hydrogen peroxid—peroxidase. The writer shows further on, however, that this assumption also is incorrect and proves that the two properties belong to two different enzyms.

The simple observation that the insoluble part of green tobacco leaves shows a much more powerful action upon hydrogen peroxid than the soluble, and that tobacco five to six years old may have the power of energetically decomposing hydrogen peroxid in the absence of any other enzym, first induced the writer to investigate the final cause of the catalytic action on hydrogen peroxid.

After this bulletin was finished the attention of the writer was called to the publication of E. Lepinois, in the Compt. rend. de la Société de Biologie of May 26, 1899, entitled "Sur les ferments solubles décomposants l'eau oxygénée." This investigator compared extracts of the thyroid gland, pancreas, liver, and ovaries with regard to their power of catalyzing hydrogen peroxid and determined how far this action is diminished by the addition of small quantities of hydrochloric acid and of potassa. While the three glands mentioned yielded nearly equal quantities of oxygen, the ovaries gave only about one-fourth as much. The final remark of this author is of some interest: "Enfin, j'ai observé qu'il n'y a pas toujours un rapport étroit entre la quantité d'oxygène

[1] Pflüger's Archiv, vol. 60, p. 303 (1895).

[2] Ibid., vol. 67 (1897).

dégagé et l'action exercée simultanément sur divers réactifs, tels que la teinture de résine de gaïac, le gaïacol, etc." (Finally, I have observed that there does not always exist a parallelism between the quantities of oxygen developed and the intensity of other reactions, as that upon tincture of guaiac, guaiacol, etc.)

## IS THE PROPERTY OF DECOMPOSING HYDROGEN PEROXID DUE TO ANY KNOWN ENZYM?

In the course of the examination of various tobacco samples for the presence of oxidase it was noticed in a sample of "Zimmer Spanish" of the crop of 1893 that an aqueous extract gave an energetic development of oxygen upon the addition of hydrogen peroxid without yielding a blue coloration in the presence of guaiac tincture.

In order to see whether other enzyms that might occur in cured and sweated tobacco were present, a concentrated extract of finely powdered tobacco was prepared in the cold in such a way that the extract of one portion was used for extracting the next portion, and so on. A small portion of boiled starch—just enough to give a distinct reaction with iodine—was added to one portion of this concentrated extract. A few drops of diluted egg albumen were added to another portion, and some amygdalin was added to a third portion. After the addition of a few drops of ether the three portions were heated in closed vessels at a temperature of 50° C. for twenty-four hours, but there was not the slightest trace of any action noticed. The iodine reaction with the first portion was of the same intensity as before. The coagulation of albumen by nitric acid in the second portion was as voluminous as before, and in the third portion no odor of benzaldehyde was noted. Another portion was tested with guaiac solution with and without the addition of hydrogen peroxid, but no blue reaction was obtained. Hence the sample contained neither diastase, proteolytic enzym, emulsin, oxidase, nor peroxidase, nevertheless the property of decomposing hydrogen peroxid was very powerful.[1]

In a second test for emulsin 3 grams of the same tobacco were finely pulverized and digested with 20 cc. water and 0.2 gram amygdalin for one hour, but no trace of prussic acid and benzaldehyde was observable. A very small amount of emulsin was now added to this mixture for control, and after a few minutes the odor of these products of hydrolysis of amygdalin was noticed. A further test was made to see whether emulsin was present in fresh tobacco leaves. The pulp

[1] It may be mentioned here that green tobacco leaves contain so little amylolytic and proteolytic enzym that it requires special tests to prove their presence. During the curing period of the tobacco leaves these enzyms are gradually destroyed. In most cases only the oxidase and peroxidase still remain active, but in the sweating period following the oxidase is in most cases wholly destroyed, while the peroxidase still exists. In course of time, two years at the longest, this enzym also disappears, and only the enzym that catalyzes hydrogen peroxid remains.

obtained by crushing such leaves was digested for several hours with diluted amygdalin solution, but no trace of decomposition of amygdalin was noticed. Here also an addition of a very little emulsin caused, almost at once, the formation of prussic acid and benzaldehyde. We may therefore be justified in concluding that neither the fermented nor the green tobacco leaves contain emulsin.[1] These tests prove that the power of developing oxygen by decomposition of hydrogen peroxid—in other words, of catalyzing hydrogen peroxid—is not due to emulsin. On the contrary, direct examination of sufficiently purified emulsin shows that it is incapable of such action. Furthermore, emulsin preparations are found in commerce which are devoid of this property, although they have a powerful action on amygdalin.

In a further test a cold-prepared, concentrated extract of the same tobacco (Zimmer Spanish, sweated 1893) was saturated with ammonium sulphate, and the precipitate, after being pressed between filter paper, was dissolved in a little water and divided into two parts. One part was mixed with some highly dilute starch paste, and the other with 1 per cent cane sugar, both mixtures being digested for two hours at 50° C. It was then evident that the iodine reaction for starch had not in the least diminished, and, further, that no invert sugar was formed; hence neither diastase nor invertase existed in this tobacco. Another sample of sweated tobacco (from Cuba) also served for a test for diastase. One gram of finely pulverized material was digested with highly dilute starch paste, with the addition of some ether, in a tightly closed flask for three hours at from 45° to 50° C. In this case, also, no decrease of starch reaction, hence no diastase, could be observed. This enzym, therefore, can not be the cause of the catalysis of hydrogen peroxid. In commerce there are powerful diastase preparations which exhibit no trace of the power of catalyzing hydrogen peroxid. Thus, a pancreatic diastase which contained a trace of peroxidase as impurity did not develop a trace of oxygen when brought in contact with a 0.5 per cent solution of hydrogen peroxid, while a sample of diastase of malt showed it in a slight degree, and a sample of taka diastase in an energetic measure. It is clear that these preparations had a different degree of purity.

A sample of the papayotin of commerce was also tested, and, while it acted powerfully on fibrin, it showed no action on hydrogen peroxid and was also free from peroxidase.

The supposition might be entertained that it is the peroxidase which possesses the characteristic property of catalyzing hydrogen peroxid. It might be assumed that it is the oxygen liberated in statu nascendi by the catalysis of hydrogen peroxid that produces the blue coloration which the peroxidase shows when tincture of guaiac and a little

[1] The assertion by Behrens (Landw. Vers.-Stat., LII, p. 438) of the presence of emulsin in cured tobacco is not sufficiently sustained.

hydrogen peroxid are added to vegetal or animal juices; but the fact is that this blue reaction can be observed in liquids which have not the least power of developing gaseous oxygen when hydrogen peroxid is added. On the other hand, certain animal or vegetable matter may show great power of catalyzing hydrogen peroxid without giving the blue peroxidase reaction. It is not, then, the nascent oxygen which leads to the oxidation of guaiac (guaiaconic acid) in the peroxidase reaction, but it is the still undecomposed peroxid of hydrogen itself which under the influence of the peroxidase produces the blue compound. Some instances may be mentioned which plainly prove that there is no direct connection between the power of catalyzing hydrogen peroxid and the property of causing the blue peroxidase reaction. There is in commerce a kind of diastase prepared from a fungus (*Aspergillus oryzæ*), the so-called taka diastase, which does not give the reaction for peroxidase, but shows the power of decomposing hydrogen peroxid in a very high degree. Since pure diastase does not show this property, as above mentioned, this diastase preparation must then contain an admixture of another active principle. On the other hand, the trypsin of commerce, prepared from the pancreatic gland, often shows the blue reaction for peroxidase without being able to catalyze hydrogen peroxid. It often contains some peroxidase as an impurity. Furthermore, the filtrate of cultures of *Penicillium glaucum* generally yields no blue reaction with guaiac either for oxidase or peroxidase, but has the power of catalyzing hydrogen peroxid in a high degree. The same is true for cultures of various bacteria.

Tobacco samples of commerce also show the power of catalyzing hydrogen peroxid, frequently to a great extent, although they may have lost the original content of oxidase and peroxidase.

A case where the blue guaiac reactions were obtained in the absence of the power of catalyzing hydrogen peroxid was observed with green tobacco leaves gathered from greenhouse plants in December. The juice was mixed with one-fifth of its volume of absolute alcohol and left for fifteen hours before filtering. Five cc. of the clear filtrate were mixed with 15 cc. water and 5 cc. hydrogen peroxid, but no trace of oxygen was given off, while the blue guaiac reactions for oxidase as well as for peroxidase (after killing the oxidase by heating to 70° C.) were obtained with considerable intensity. The property of catalyzing hydrogen peroxid was here observed only with the insoluble parts of the leaf. In the following chapters further instances will be mentioned which prove that these two reactions are produced by different principles.

Since it is clear that the power of catalyzing hydrogen peroxid is not due to any of the known enzyms, it appears justifiable to ascribe this power to a special enzym. The writer proposes to call this catalase.[1]

[1] The objection might be raised that this name would apply to every other enzym as well, but this objection does not carry much weight.

## TWO KINDS OF CATALASE.

It was one of the first observations of the writer when he commenced the study of the new enzym that it existed in an insoluble and in a soluble form. These may be distinguished as $\alpha$- and $\beta$-catalase, respectively. The former is probably a compound of the soluble catalase with a nucleo-proteid, while the soluble catalase is an albumose and can be liberated by the action of very dilute alkaline media upon the insoluble catalase. This conversion can be observed well in the process of sweating tobacco in bulk, whereby the temperature gradually reaches 60° C., and ammonium carbonate is generated as one of the products of the destructive processes going on. Cured tobacco contains but little soluble catalase, while well-sweated tobacco contains much. For example, it was observed that the cold-prepared aqueous extract of 2 grams of cured tobacco yielded in thirty minutes, on the addition of dilute hydrogen peroxid in excess, only 16.5 cc. of oxygen, while the same tobacco after sweating in bulk yielded 236 cc. under similar conditions.

Sometimes sweated tobacco proves rich in $\beta$-catalase, as may be inferred from the following test. Five grams of finely powdered tobacco (Zimmer Spanish) were digested for twenty-four hours with 500 cc. of cold water, with the addition of some chloroform. Twenty cc. of this highly diluted extract yielded in thirty minutes, upon the addition of 5 cc. hydrogen peroxid, 34 cc. oxygen.[1]

Crude $\beta$-catalase is obtained by preparing at the ordinary temperature a concentrated extract from tobacco sweated in bulk, with water containing chloroform, using the same water for extracting three or four portions of the tobacco. This extract is saturated at the ordinary temperature with ammonium sulphate. The precipitate thus obtained is dried at the room temperature between sheets of filter paper, which removes most of the adhering salt solution. This crude product contains, among other substances, besides adhering ammonium sulphate, a brown coloring matter which can not be removed by digesting the solution with boneblack, since this absorbs the dissolved enzym also. The ammonium sulphate can be removed by osmosis, and the enzym may then be precipitated by alcohol. The activity is better preserved, however, when the fresh moist precipitate is dissolved in some glycerol. Colorless products can be prepared from the seeds of clover or poppy; but these preparations are weaker than that from sweated tobacco, since they contain more impurities, among which may be found a little peroxidase. A very energetic product may be

[1] The hydrogen peroxid preparation mentioned in this bulletin refers to the commercial article. It contained from 2.8 to 3.1 per cent pure hydrogen peroxid. The weak acid reaction was removed immediately before use by diluted sodium hydrate or carbonate. A preparation yielding ten times its volume of oxygen by catalysis contains 3.04 per cent of pure peroxid by weight.

obtained from culture fluids of *Penicillium glaucum* in the manner above described. The crude $\beta$-catalase from animal organs contains more proteins as impurities than that from sweated tobacco.

While $\beta$-catalase[1] behaves like an albumose, $\alpha$-catalase behaves like a nucleo-proteid, since it is not soluble in water alone. It can be brought into solution by dilute alkaline liquids and precipitated again therefrom unchanged on the addition of acetic acid.[2] Sweated tobacco was finely pulverized and repeatedly extracted with a large amount of cold water, to which a few drops of ether had been added in order to prevent bacterial growth, and then treated for fifteen hours with a 0.2 per cent solution of caustic soda. This alkaline extract, after filtering, was cautiously acidulated with acetic acid (mere neutralization does not yield a precipitate), and the precipitate filtered off after standing one hour. This precipitate possessed, in a considerable degree, the power of decomposing hydrogen peroxid, while the liquid filtered from it did not show this power in the least. This behavior was also observed with green tobacco leaves. Six hundred square centimeters of healthy tobacco leaves from the greenhouse were crushed to a fine pulp with sand and left for three hours in contact with a 0.2 per cent solution of ammonium carbonate. The opalescent filtrate obtained had in a high degree the power of catalyzing hydrogen peroxid. Upon adding dilute acetic acid until a slight acid reaction was reached, a fine flocculent precipitate containing the active principle was formed, the filtrate from this precipitate being devoid of the catalyzing property.

The $\alpha$-catalase is, however, not very readily extracted by alkaline liquids. Even a 1 per cent solution of sodium carbonate dissolves it but slowly. The solution thus obtained from sweated tobacco that had been well exhausted with water before the treatment with sodium carbonate was begun does not give the characteristic blue reactions for oxidase and peroxidase (a previous slight acidulating of the alkaline liquid is necessary for these tests), hence $\alpha$-catalase also has no close relation to these two oxidases. In these tests 10 per cent alcohol was added to the extracting liquids to prevent bacterial growth during the time of extraction.

Connecticut tobacco, cured in 1899, was repeatedly extracted with water saturated with chloroform. After the removal of the soluble compounds this tobacco was left for two days with a 0.5 per cent solution of sodium carbonate, just enough to cover the soaked tobacco with the solution. Then the liquid was separated from the tobacco and 20 cc. of the brown-colored filtrate mixed with 5 cc. hydrogen peroxide, and in fifteen minutes 7.5 cc. of oxygen were obtained. A

[1] Special tests have shown that it is not a coagulable albumin.

[2] This militates against the supposition that $\alpha$-catalase might be merely $\beta$-catalase in a state of absorption, the same way that colored matters are absorbed by charcoal.

quantity of the expressed residue corresponding to nearly 2 grams of dry matter, after being washed well and again expressed, was suspended in 20 cc. water and 10 cc. hydrogen peroxid added; in fifteen minutes 31 cc. of oxygen were obtained. This shows that a solution of 0.5 per cent sodium carbonate did not extract all the $\alpha$-catalase even in two days.

It is more difficult to prepare the $\alpha$-catalase free from peroxidase when using green tobacco leaves than when cured and fermented leaves are used, since it takes a long time to wash out the peroxidase from the pulp prepared from the fresh leaves. For example, 30 cc. of turbid, not filtered, juice prepared from tobacco leaves was mixed with ten times this quantity of water and filtered after standing fifteen hours, leaving a green residue in the filter, which even after prolonged washing yielded the reaction for peroxidase, while that for oxidase had ceased to be produced in the wash waters after a short time.

Water alone dissolves only traces of $\alpha$-catalase at 20° C., while prolonged action of water at a moderate elevation of temperature gradually splits off $\beta$-catalase, the process being favored by adding a small proportion of sodium carbonate.

The following test shows that even very large quantities of water alone do not extract $\alpha$-catalase to any noticeable extent. Two grams of finely pulverized cured tobacco were extracted for four hours with 40 cc. of water at 20° C. and the residue washed until the filtrate was nearly colorless. This extracted tobacco yielded in fifteen minutes, upon the addition of 5 cc. hydrogen peroxid and 20 cc. water, 42 cc. oxygen. Two grams of the same tobacco were now extracted with 1 liter of chloroform water for eighteen hours. The powder yielded, after washing under the same conditions as before, 40 cc. oxygen.

It seems strange that neither Schœnbein nor Jacobson observed that the property of catalyzing hydrogen peroxid may be due to a soluble as well as to an insoluble substance. Schœnbein mentions only once—without, however, altering his opinion that the enzyms were the cause of that catalysis—that the filtered extracts of certain vegetable matter show much less power of catalyzing hydrogen peroxid than the unfiltered. Jacobson also used, in his experiments mentioned above, the crude turbid extracts, but not purified enzym preparations. He used, for instance, an emulsion prepared from crushed almonds instead of purified emulsin.

The following tests leave no doubt that the transformation from the insoluble to the soluble catalase really can take place. Sweated tobacco rich in $\alpha$-catalase was finely pulverized, repeatedly extracted with chloroform water[1] at the ordinary temperature, and, when $\beta$-catalase

[1] Care must be taken in the application of chloroform water as an antiseptic that a full saturation is preserved, otherwise certain microbes will gradually develop.

could no longer be extracted, heated with a 1 per cent solution of sodium carbonate for one hour at 40° C. The mixture was passed through flannel and the filtrate moderately acidulated with acetic acid to precipitate nucleo-proteids. The clear filtrate now obtained had a considerable power of catalyzing hydrogen peroxid, although it could not contain $\alpha$-catalase any longer.

In a second trial the exhausted tobacco was heated for two hours at from 45° to 50° C., with a solution of 0.2 per cent sodium carbonate, the filtrate acidulated with acetic acid, again filtered, and the filtrate now saturated with ammonium sulphate at the ordinary temperature. By this treatment the active principle was salted out, as is the case with $\beta$-catalase, the precipitate showing powerful action while the filtrate showed only slight traces of activity. It may also be stated that the salted-out product was easily soluble again in water and can not therefore have consisted of nucleo-proteids.

Since there is a zymogen for every well-known enzym, the supposition seems justifiable that there is also a zymogen of catalase. Various observers have shown that animal or vegetable cells, before they form the enzyms, are rich in small granules, which disappear in a measure as the enzyms are formed. The substance first secreted by the nucleus, forming the granules in the cytoplasm, is distinguished by Macallum as pro-zymogen. Vines, in his investigation on the presence of diastase in leaves, observed that the turbid unfiltered extracts saccharified more starch than the clear filtered ones. Brown and Morris found, furthermore, that powdered leaves are more powerful in diastasic action than an aqueous extract prepared from the same amount of leaf. Whether the action here is caused by a zymogen which is gradually transformed into diastase, or whether the diastase itself is retained to a certain extent by the solid compounds of the leaf, has not been decided. It has been observed that highly dilute acids bring on the transformation of zymogen into enzym. J. Reynolds Green has found that certain rays of light—located chiefly in the red, orange, and blue regions of the spectrum—and a prolonged exposure to a temperature of 38° C. can also cause this change.[1]

The existence of a zymogen of catalase in tobacco leaves appears probable from an observation of the writer that in the process of sweating tobacco in bulk at a temperature of from 40° to 50° C. the power of catalyzing hydrogen peroxid is increased, not only for the soluble but also for the insoluble catalase. Digestion with 0.1 per cent oxalic acid at from 25° to 36° C. proved a failure in this direction, since the catalytic power was decreased thereby. Acids therefore seem unsuited to transform zymogen into enzym in the case of catalase.

[1] Philosoph. Transactions, vol. 188 (1897). On the other hand, diastase itself is gradually destroyed by white light, as the same author has observed.

EFFECTIVENESS OF THE β-CATALASE.

For the following tests a preparation of crude β-catalase was used which was obtained by salting out with ammonium sulphate a concentrated cold-prepared extract of tobacco recently sweated in bulk. The precipitate, after being pressed between filter paper, was permitted to dry at the room temperature. A 1 per cent solution of this crude β-catalase, still containing a considerable amount of ammonium sulphate, was prepared. One cc. of this solution was mixed with 20 cc. of water and 2 cc. of common hydrogen peroxid (neutralized). The volume of oxygen evolved for different lengths of time was as follows:

| | cc. |
|---|---|
| After 5 minutes | 12 |
| After 10 minutes | 17 |
| After 16 minutes | 20.2 |

This result shows that in the dilution of 1:2,000 the crude enzym decomposed six times its own weight of anhydrous hydrogen peroxid in sixteen minutes.

In the next test the reaction of the mixture was kept slightly alkaline and the amount of hydrogen peroxid increased to 10 cc., the other conditions being the same as before:

| | cc. |
|---|---|
| After 5 minutes | 20 |
| After 10 minutes | 38 |
| After 15 minutes | 55 |
| After 40 minutes | 76 |
| After 55 minutes | 80 |
| After 15 hours | 101.5 |

In a further test 1 cc. of the 1 per cent catalase solution mentioned above was diluted with 200 cc. water and 1 cc. hydrogen peroxid added. One minute after the mixture was made the reaction for hydrogen peroxid was still very powerful.[1] After twenty-five minutes, however, the reaction was very weak, and after thirty-two minutes there was no trace of hydrogen peroxid left. This test was repeated with the modification that the amount of water was increased to 500 cc. and the amount of hydrogen peroxid decreased to 0.5 cc. After twenty-one minutes the reaction for hydrogen peroxid was very much weaker than in the beginning, and after fifty minutes no reaction at all was obtained. This shows that even in a dilution of 1:50,000 the crude enzym was still very active. In the control case, where the solution of the enzym was boiled for a second, the reaction for hydrogen peroxid did not decrease to any noticeable degree within the same length of time.

While catalase attacks hydrogen peroxid very readily, the hydrogen peroxid also has, when applied in moderate concentration, a directly

[1] The test was made with iodide of potassium, starch, and a trace of ferrous sulphate.

oxidizing influence upon the enzym. This accounts for the rapid decrease of the amount of oxygen developed and for the fact that a point is reached comparatively soon where the enzym becomes entirely inactive. Sweated tobacco, 0.1 gram of which developed 32 cc. of oxygen in fifteen minutes when suspended in a mixture of 10 cc. water with 5 cc. hydrogen peroxid, did not develop any more after the same quantity had been left for fifteen hours in contact with 25 cc. of the same mixture. It may safely be assumed that the detrimental effect of hydrogen peroxid is diminished very much by high dilution.

The activity of $\beta$-catalase increases up to a temperature of about 40° C. With further elevation of the temperature the oxidizing action of hydrogen peroxid upon the enzym becomes more powerful than the catalytic action of the enzym upon the hydrogen peroxid, and the enzym very soon loses its activity. A solution was prepared of 0.2 per cent crude $\beta$-catalase obtained from sweated tobacco in the manner above described. Thirty cc. of this solution were heated to determined temperatures, and after addition of 5 cc. of hydrogen peroxid of 20° C. the time required for the development of a certain volume of oxygen was noted. At 50° and 60° C. the action was energetic for one minute only, after which it slowed down rapidly and stopped.

*Effect of heat on action of $\beta$-catalase.*

| Temperature. | Duration of test. | Volume of oxygen. | Remarks. |
|---|---|---|---|
| ° C. | *Minutes.* | cc. | |
| 20..... | 5¼ | 40 | |
| 40..... | 3¼ | 40 | |
| 50..... | 4 | 29 | Action stopped after 4 minutes. |
| 60..... | 2 | 23 | Action stopped after 2 minutes. |

## GENERAL BEHAVIOR OF $\alpha$- AND $\beta$-CATALASE.

Both the soluble and the insoluble catalase resist the effects of time longer than the ordinary oxidases, as has already been mentioned. The writer examined leaves of various species of *Solanum*, collected in 1841, 1848, 1853, and 1868 (preserved as herbarium specimens), and observed in all of these the production of oxygen upon the addition of hydrogen peroxid. The leaves were first soaked in a little water before the hydrogen peroxid was added. The leaves collected in 1841, however, showed only a weak action.

In an aqueous solution, free from bacteria, $\beta$-catalase loses its power either by self-oxidation or by changes within the molecule by atomic migration, but this change is also sometimes relatively slow. Once, however, the writer observed this enzym in a six-months-old culture of *Bacillus pyocyaneus*, in which growth of the germ had apparently stopped for several months.

In aqueous solution the $\beta$-catalase is chemically changed to an inac-

tive substance on heating to from 71° to 75° C. The degree of temperature at which the enzym is "killed" depends upon the time of exposure. At 72° C. more than fifteen minutes are required, while a much shorter time suffices at 74° C. Heating but for a second to 75° is not sufficient to kill all the enzym in a neutral solution, but it will injure a great part of it. In a very weak alkaline solution the killing temperature is raised several degrees, but the contrary is true when this alkaline reaction is increased still a little more. In slightly acidulated solutions the killing temperature is lower than in neutral ones.

The killing temperature of $\alpha$-catalase is about the same as that of $\beta$-catalase. Green tobacco leaves were crushed and the juice expressed through flannel. This turbid liquid of acid reaction was passed through a filter, and the filter content, rich in $\alpha$-catalase, suspended in water and heated to various temperatures. Heating for ten minutes to 60° C. did not decrease the intensity of the catalytic power, but heating for five minutes to 71° C. injured it considerably. After heating for five minutes to 75° C. and cooling quickly a faint trace of that power was still observed, but no trace was noticeable after heating for one minute to 80°. The filtered liquid in the latter case still contained considerable active peroxidase, another proof that this enzym can not be identified with catalase.

In a dry condition catalase resists heat better than in the presence of water. For example, fermented tobacco leaves when heated for two hours to 100° C. had not completely lost their content of $\alpha$- and $\beta$-catalase, although it was very much decreased. A prolonged application of heat, however, kills these enzyms at 80° C., even in the absence of water, as may be inferred from the inactivity of fire- and flue-cured tobacco (cigarette tobacco). Various samples of such products were tested, and in most cases no trace of either $\alpha$- or $\beta$-catalase could be observed.

### EFFECT OF MECHANICAL MOTION ON THE REACTION WITH HYDROGEN PEROXID.

It is remarkable to what extent the action of the soluble catalase is promoted by shaking the mixture. One out of many of the observations may be mentioned here. A cold-prepared aqueous extract of sweated tobacco (20 cc.) was mixed with half its volume of hydrogen peroxid and the flask left untouched. In the control case the flask was continuously shaken. The amount of oxygen developed in thirty minutes, not shaken, was 24 cc.; shaken, was 51 cc. The oxygen developed under the influence of mechanical motion was therefore more than double the amount obtained when the flask was left undisturbed.[1]

[1] It hardly needs to be mentioned that in all experiments described in this paper the mixtures with hydrogen peroxid were frequently shaken during the observations in order to obtain the full reaction. Heating the mixtures was never resorted to; on the contrary, any rise of temperature was avoided.

BEHAVIOR TOWARD VARIOUS SALTS.

A careful distinction should be made here between the relation of a salt to the enzym itself and the influence of a salt upon its activity alone. This activity can be stimulated or retarded without the enzym itself being changed in its chemical nature. Salts of a strong acid or alkaline reaction will of course injure the enzym itself, while salts of neutral reaction will probably not do so. Thus, $\alpha$-catalase is not injured in one day by a 10 per cent solution of magnesium sulphate, nor in five hours by a 5 per cent solution of sodium sulphate, nor in twenty hours by a 2 per cent solution of potassium persulphate,[1] nor in one day by a saturated solution of ammonium sulphate. After these salts are removed by careful washing the $\alpha$-catalase contained in sweated tobacco is found fully preserved, or very nearly so. It is very probable that $\beta$-catalase is more easily injured, but nevertheless it can even be salted out by saturation of its solution with ammonium sulphate without immediate loss of power, although the subsequent drying at the ordinary temperature with the adhering salt leads to a partial loss of its activity.

A concentrated extract was prepared at the ordinary temperature from sweated tobacco (Connecticut crop of 1899) rich in $\alpha$- and $\beta$-catalase, and containing no oxidase and only a trace of peroxidase. Ten cc. of this extract were mixed with 20 cc. of hydrogen peroxid (added in two doses), and in five minutes 160 cc. of oxygen were developed. By saturation with ammonium sulphate a brown-colored precipitate of great catalytic energy was obtained, while the filtrate showed only a trace of activity. After being collected on a filter and dried for twenty-four hours at the ordinary temperature on a porous plate, the precipitate weighed 2.85 grams, more than half of which, however, consisted of adhering ammonium sulphate. Half a gram of this powder dissolved in 20 cc. of water in five minutes developed 223 cc. oxygen, and in fifteen minutes 449 cc.[2]

The considerable depression of the catalytic activity of $\beta$-catalase by nitrates is very remarkable. The enzym itself does not seem to be injured materially, as several tests have shown. For example, a very small quantity of a $\beta$-catalase preparation, obtained by salting out a cold-prepared concentrated tobacco extract with ammonium sulphate, was kept in a 10 per cent solution of potassium nitrate for twenty-

[1] It might be supposed that this salt would exert an oxidizing action detrimental to the enzym, but such indifferent behavior of the salt has been noticed in other cases also; for example, toward certain aniline colors. (Proscher, Chem.-Zeitung, March, 1900.) Potassium persulphate easily oxidizes hydroquinone to quinone, $\alpha$-naphthylamine to the blue oxynaphthylamine, and behaves in its oxidizing property like ferric chlorid.

[2] The observation of Jacobson that the "catalytic power" of a pancreas extract, or of an emulsion of almonds, is lost by saturation with sodium sulphate, is probably due to his drying the salted-out product at a higher temperature.

four hours, again salted out by ammonium sulphate, and washed well by a concentrated solution of this salt. Upon redissolving it in 20 cc. water and adding 10 cc. hydrogen peroxid, it still developed 92 cc. oxygen in fifteen minutes, while in the control case 98 cc. were obtained; hence the enzym itself is not injured by potassium nitrate.

The depressing influence of nitrates is seen from the following test: Two portions of an extract of sweated tobacco received an addition of 5 per cent potassium nitrate and 5 per cent magnesium sulphate (cryst.), respectively. Immediately afterwards 20 cc. of each of these liquids were mixed with 10 cc. hydrogen peroxid. The result was:

*Oxygen developed in five minutes.*

| | cc. |
|---|---|
| In presence of potassium nitrate[1] | 15 |
| In presence of magnesium sulphate | 88 |
| Control | 105 |

Nitrates have no such depressing influence upon the corresponding action of finely divided platinum. A mixture was prepared of 5 cc. hydrogen peroxid, 20 cc. water, 2 grams potassium nitrate, and a trace of platinum black. Here 28 cc. oxygen were developed in fifteen minutes, while in the control case 31.6 cc. were evolved. This shows that the contact of the nitrate with the enzym itself can be the only cause of the retardation just mentioned.

In some other tests the time necessary to develop a certain volume of oxygen was observed. One gram of crude $\beta$-catalase, prepared by salting out a concentrated extract of sweated tobacco and drying at the ordinary temperature, was dissolved in 500 cc. water. To different portions, each containing 5 cc., of this highly diluted solution, 20 cc. water and 0.5 gram of various salts were added. After a further addition of 5 cc. of nearly neutral hydrogen peroxid the time necessary for the production of 40 cc. of oxygen was observed. The mixture was frequently shaken. The number of minutes required to produce 40 cc. of oxygen in the presence of various salts was as follows:

| | Minutes. |
|---|---|
| With sodium chlorid | 4¾ |
| With potassium chlorid | 4¾ |
| With dipotassium phosphate | 4¾ |
| With potassium nitrate | 8½ |
| With sodium nitrate | 6½ |
| With ammonium nitrate | 10½ |
| With calcium nitrate | 3¾ |
| Without addition of salts—control | 4½ |

While in this case the mixtures had a weak acid reaction, they had in the following experiment a weak alkaline reaction. The enzym, furthermore, was applied in double the concentration used before, and, with one exception, the amount of salts applied was increased to

[1] The depression of the catalytic power of pancreas and almond extract by potassium nitrate was also observed by Jacobson in 1892.

2 grams. Here the time required to produce 48 cc. of oxygen under otherwise the same conditions as before was noted.

The number of minutes required to produce 48 cc. of oxygen in the presence of various salts was as follows:

| | Minutes. |
|---|---|
| With sodium chlorid | 3 |
| With potassium chlorid | 3¾ |
| With potassium nitrate | 4½ |
| With sodium sulphate | 3 |
| With potassium sulphate | 4 |
| With sodium carbonate (0.5 gram) | 2 |
| With sodium carbonate (2 grams) | 4¼ |
| Without addition of salts—control | 3 |

It will be noticed that potassium salts retard the reaction more than sodium salts, and that the nitrates of the alkali group retard more than the other salts. In general, the increase of the amount of any salt has a retarding influence, other things being equal, and it was found in a special case that saturation of the liquid with sodium chlorid retarded the action of the enzym so as to require more than double the time to produce the given amount of oxygen.

Sodium carbonate (anhydr.) attacks $\beta$-catalase but very slowly even in a 3 per cent solution. Even after fifteen hours at low temperature the enzym is only partially killed. To a solution of which 20 cc. produced 17.8 cc. of oxygen in fifteen minutes, 5 per cent of its bulk of sodium carbonate (anhydr.) was added in the form of a concentrated solution. After standing fifteen hours at 0° C. it was neutralized with acetic acid and, after the removal of the carbon dioxid by a current of air, 5 cc. hydrogen peroxid were added. There were still produced 7.2 cc. oxygen in fifteen minutes. More injury is caused by heating the solution for one minute with 2 per cent of sodium carbonate to 40° C, only 5 cc. oxygen being produced afterwards in fifteen minutes. Scarcely any injury is observed after fifteen hours' contact at 15° C. with a 1 per cent solution of sodium carbonate, and even after standing at the ordinary temperature for three days there is still considerable active enzym present in the solution.

No injury whatever is caused in twenty-four hours by a 2 per cent solution of sodium fluorid or by a 5 per cent solution of dipotassium oxalate. Neither a 5 per cent solution of potassium sulpho-cyanide nor of thio-urea has any apparent injurious influence upon the $\beta$-catalase. The presence of these compounds seriously interferes, however, with the reaction of the enzym upon hydrogen peroxid, since potassium sulphocyanide is rapidly oxidized by hydrogen peroxid to monopotassium sulphate and prussic acid,[1] while thio-urea is transformed into sulphuric acid and (partly) carbamide.[2] These mixtures rapidly

[1] $KCNS + 3H_2O_2 = KHSO_4 + HCN + 2H_2O$.

[2] $CSN_2H_4 + 4H_2O_2 = SO_4H_2 + CON_2H_4 + 3H_2O$.

assume a very acid reaction. In the latter case a considerable rise of temperature is noticed.[1]

BEHAVIOR TOWARD MERCURIC CHLORID.

Two grams of cured tobacco containing $\alpha$- and $\beta$-catalase were left two days in 2 cc. of a 0.1 per cent solution of mercuric chlorid. While the filtrate showed no reaction whatever on hydrogen peroxid, the insoluble part still showed a slight reaction. Suspended in 30 cc. water, it yielded on addition of 10 cc. hydrogen peroxid:

*Oxygen in thirty minutes.*

| | cc. |
|---|---|
| After treatment with $HgCl_2$ | 6 |
| Control | 158 |

This reveals a highly injurious influence of mercuric chlorid on both kinds of catalase. The $\beta$-catalase of one gram of the sample yielded 16.5 cc. oxygen in thirty minutes. Hence, even on the assumption that all $\beta$-catalase had been merely precipitated by the mercuric chlorid and thus withdrawn from the solution, and further assuming that it was in the first place the $\alpha$-catalase that had been killed by that salt, an injury due to $\beta$-catalase would still be evident.

Catalase is probably also injured by various salts of other heavy metals, but the results obtained upon addition of hydrogen peroxid to such mixtures would be misleading, since many salts of these metals themselves bring on decomposition of hydrogen peroxid.

BEHAVIOR TOWARD ACIDS AND BASES.

It is a noticeable fact that while highly dilute acids retard the action of $\alpha$- and $\beta$-catalase, dilute alkaline solutions promote it. In one case it was shown that on addition of 1 per cent sodium carbonate to a mixture of 10 cc. cold-prepared tobacco extract with 10 cc. hydrogen peroxid, 165 cc. of oxygen were developed in five minutes, while it took fourteen minutes to develop the same amount of oxygen when sodium carbonate was absent.

When the amount of acids in the solutions reaches more than 0.5 per cent, the $\alpha$- and $\beta$-catalase are very soon killed. The following observations may be mentioned: Two grams of finely powdered sweated tobacco were shaken with 40 cc. of a 2 per cent solution of oxalic acid and the mixture neutralized after thirty minutes, with caustic soda. The catalytic power was entirely destroyed. No trace of oxy-

[1] Jacobson's inferences as to the injurious influence of potassium sulpho-cyanide upon the "catalytic property of diastase, emulsin, etc.," must be corrected accordingly, since it is the acid reaction of mono-potassium sulphate formed by the hydrogen peroxid which interferes with the result, and not the sulpho-cyanide as such. Furthermore, it is not diastase and emulsin, but a separate enzym, that causes the "catalysis of hydrogen peroxid" as here set forth.

gen was developed either by the extract or by the residue. In a second test, solutions of 0.2 per cent oxalic and sulphurous acids were permitted to act for eighteen hours under the same conditions mentioned above. The $\beta$-catalase was almost entirely destroyed and the $\alpha$-catalase was also considerably injured.

The number of cubic centimeters of oxygen developed by $\alpha$-catalase in thirty minutes was as follows:

| | cc. |
|---|---|
| Control | 158 |
| With 0.2 per cent oxalic acid | 33 |
| With 0.2 per cent sulphurous acid | 28 |

A solution of 0.1 per cent acetic acid at the ordinary temperature did not injure the catalytic power in one hour, but injured it gradually at a temperature of 55° C.

When sweated tobacco was suspended in fifty times its weight of a 2 per cent sulphuric acid solution the catalytic power was destroyed in fifteen minutes.[1] A solution of $\beta$-catalase lost its activity in fifteen minutes after the addition of 1 per cent sulphuric acid. $\alpha$-catalase behaves the same, as was shown on suspending tobacco in fifty times its weight of 1 per cent sulphuric acid.

Saturated baryta water kills $\beta$-catalase in two days, but only slowly injures $\alpha$-catalase, as shown[2] in an experiment with 2 grams cured tobacco suspended in twenty-five times its weight of baryta water. After neutralization with acetic acid and addition of 5 cc. hydrogen peroxid, the amount of oxygen developed in 15 minutes was as follows:

| | cc. |
|---|---|
| $\alpha$-catalase | 33 |
| $\beta$-catalase | 0 |
| Control to $\beta$-catalase | 89 |

Sodium hydrate in a dilution of 1 per cent kills $\alpha$- and $\beta$-catalase almost instantly, while a dilution of 0.1 per cent has no injurious influence, at least not within a short time.

### BEHAVIOR TOWARD ALCOHOL.

Absolute alcohol injures neither $\alpha$- nor $\beta$-catalase at the ordinary temperature in twenty hours. One gram of sweated tobacco was mixed with 10 cc. absolute alcohol.[3] The alcohol was filtered off

[1] It may here be mentioned that in all such cases the liquid was neutralized with dilute caustic soda before the hydrogen peroxid was added. An excess of the dilute acid had to be applied, since the tobacco often contains 10 per cent and over of salts of organic acids (malic, citric, oxalic acids).

[2] Of course a small part of the dissolved baryta was rendered inactive by combination with the acids bound to the ammonia and nicotine contained in the tobacco, but this fact, considering the large amount of baryta water, does not essentially alter the above inference.

[3] While absolute alcohol does not dissolve a trace of the enzym, alcohol of a strength of 50 per cent dissolves a considerable amount.

after twenty hours and the tobacco powder, after being freed as much as possible from the adhering alcohol by pressure between filter paper, was extracted with 20 cc. water for three hours at the ordinary temperature. The filtrate, as well as the undried residue, yielded almost exactly as much oxygen in fifteen minutes as was obtained in the control case, showing that alcohol does not act injuriously on the enzym, at least not within a short time.

A concentrated cold-prepared extract of sweated tobacco was mixed with one-tenth of its volume of alcohol and left in a filled, well-stoppered flask for five days in a dark box at a temperature of from 15° to 18° C. There was no indication of bacterial growth. Twenty cc. of this liquid gave in ten minutes 37 cc. oxygen, while in the control case 50 cc. were originally obtained. The action of catalase on hydrogen peroxid is not influenced by the presence of small quantities of alcohol, but larger quantities—above 30 per cent—exert a retarding influence, especially noticeable when the amount of catalase present is but small.

The action of boiling absolute alcohol is of some interest. One gram of sweated tobacco was kept for half a minute in boiling absolute alcohol and then, after the removal of most of the alcohol by pressure between filter paper, extracted with cold water. Upon addition of 10 cc. hydrogen peroxid to the filtrate, as well as to the residue suspended in 20 cc. water, the following results were obtained:

*Cubic centimeters of oxygen developed in twenty minutes.*

| | By α-catalase. | By β-catalase. |
|---|---|---|
| Treated | 55 | 3 |
| Control | 70 | 20 |

The remarkable fact that boiling absolute alcohol does not instantly kill the enzym is probably due in part to the fact that all enzyms resist a higher temperature in the absence of water than when dissolved in water, and also to the fact that alcohol boils at a comparatively low temperature.

### BEHAVIOR TOWARD CHLOROFORM.

A concentrated aqueous extract of sweated tobacco was left with some chloroform for five days in a dark box. Then, after the evaporation of the chloroform at the ordinary temperature, 20 cc. of the liquid were mixed with 6 cc. of hydrogen peroxid. In ten minutes the volume of oxygen obtained was:

| | cc. |
|---|---|
| Treated | 48 |
| Control[1] | 54 |

[1]The control test was made with an equal amount of the same extract before the experiment was begun.

After standing twelve days another portion of the same extract had lost considerably more of its catalytic power, only 14.5 cc. of oxygen being developed in the same time.

In another trial sweated tobacco was first exhausted with water to remove all $\beta$-catalase and then left in chloroform water at the ordinary temperature for four weeks. It still showed a moderate reaction upon hydrogen peroxid, showing that some $\alpha$-catalase was still present. No $\beta$-catalase had here been formed from the insoluble catalase.

The action of catalase upon hydrogen peroxid is not influenced in a marked degree by the presence of a little chloroform or ether.[1]

### BEHAVIOR TOWARD PHENOL.

To an extract of sweated tobacco rich in $\beta$-catalase was added 0.2 per cent phenol, but after twenty-four hours' contact not the least decrease of catalytic power was observed. In another case the extract was completely saturated with phenol, and thus contained 6.6 per cent of it, but here every trace of catalytic power was annihilated after twenty hours.

The presence of 1 per cent phenol retards the action of the enzym. One-tenth gram of crude catalase was dissolved in 30 cc. water, and 10 cc. of this solution yielded, on addition of 5 cc. hydrogen peroxid, 25 cc. oxygen in fourteen and one-half minutes when 1 per cent phenol was present, while in the absence of the latter it took only eleven and one-half minutes to develop the same volume.

### BEHAVIOR TOWARD VARIOUS OTHER REAGENTS.

The inquiry as to the nature of the activity of enzyms led the writer years ago to the assumption that in their molecules there are certain unstable atomic groupings (labil atomic groups). Such groups are on the one hand able to transform heat energy into chemical energy, and on the other hand are readily changed by atomic migration under the influence of an increased temperature or powerful compounds, such as acids, etc. The writer has expressed the view that the instability as well as the activity of enzyms might be due to the simultaneous presence of amido and aldehyde groups. In regard to the labil amido groups, their presence was rendered probable by the destructive action which formaldehyde exerts upon the power of the enzyms. As to the presence of aldehyde, or also of ketone groups, no convincing reactions could be obtained, but it remains still to be seen whether there are not aldehyde groups present in a less reactive polymerized form. The following tests with catalase were made, to characterize the labil groups:

[1] According to Jacoby, chloroform acts as a stimulant on the activity of certain oxidizing enzyms (Virchow's Archiv. vol. 157), and according to Vogel (1897) very small doses of various ethers stimulate the cellular respiration.

ACTION OF FORMALDEHYDE.

Fifty cc. of a weak alkaline solution of $\alpha$-catalase were mixed with 10 cc. commercial formalin[1] previously neutralized. Of this mixture 20 cc. were immediately mixed with 5 cc. hydrogen peroxid, the amount of oxygen developed in ten minutes being as follows:

| | cc. |
|---|---|
| After action of formaldehyde | 3 |
| Control | 52 |

A diluted solution of $\beta$-catalase was mixed with 10 per cent of neutralized formalin, causing the formation of some precipitate. After twenty minutes 20 cc. were mixed with 5 cc. hydrogen peroxid and still 1 cc. oxygen was obtained, but after standing one hour no trace was produced. In the control case 44 cc. were developed in ten minutes.

ACTION OF NITROUS ACID.

Neither $\alpha$-nor $\beta$-catalase is injured by a 5 per cent solution of sodium nitrite at the ordinary temperature within one day, provided the solution is neutral or weakly alkaline, but as soon as the mixture is acidulated the enzym is injured by the nitrous acid liberated.

A special test showed that 0.4 per cent free nitrous acid injured the enzym considerably in one day. One-tenth gram of crude catalase was dissolved in 100 cc. water. Chloroform was then added and the solution shaken and divided into three equal parts. One part received no addition. The second part received an addition of 0.2 gram of acetic acid, and the third part 0.2 gram of acetic acid and 0.22 gram of sodium nitrite. After standing one day these solutions were made slightly alkaline before 5 cc. of hydrogen peroxid were added. The volumes of oxygen developed in 1½ minutes were:

| | cc. |
|---|---|
| Control | 40 |
| After treatment with acetic acid | 8.4 |
| After treatment with nitrous acid | 2.5 |

The loss of activity under the influence of formaldehyde or of nitrous acid renders the supposition very probable that labil amido groups are concerned in the activity of the enzym, since labil amido groups are very readily acted upon, even in neutral and highly dilute solutions, by those compounds.[2] Here we have before us a specific action, while the loss of activity under the influence of hydrochloric, sulphuric, or

[1] The preparation contained about 40 per cent pure formaldehyde and had only a slightly acid reaction. It may be mentioned that this aldehyde in dilute and neutral solution is acted upon but slowly by hydrogen peroxid; hence this influence can be neglected here.

[2] The detrimental action of mercuric chlorid above mentioned might most easily be explained by the reaction of this salt upon labil amido groups in which hydrogen can easily be replaced by mercury. By such a chemical change of an active atomic group the activity of the enzym itself is inhibited or destroyed.

oxalic acids indicates merely the loss of lability by atomic migration without giving a decided answer as to the nature of the labil atomic groups themselves.

The next question to be considered is: By what other groups in the molecule is the lability of those amido groups induced? The following tests do not give a satisfactory answer to this question, but seem to indicate that neither ordinary aldehyde nor ketone groups are the cause. The supposition as to the presence of polymerized aldehyde groups, however, still remains to be considered, especially the detrimental action of free hydroxylamine, which might be explained by a dismemberment of a polymeric aldehyde group and subsequent reaction with the hydroxylamine.

ACTION OF PRUSSIC ACID.

One gram of tobacco containing $\alpha$- and $\beta$-catalase was mixed with 20 cc. of dilute (2 per cent) prussic acid and the liquid was filtered after two hours. Ten cc. hydrogen peroxid were added to the filtrate, but no trace of oxygen was obtained. In the control case, however, 20.2 cc. of oxygen were developed in fifteen minutes. The residue in the filter was also tested after washing, but here the full original power—60 cc. of oxygen in fifteen minutes—was observed. In a second experiment the same dilute prussic acid was allowed to act on the tobacco for twenty hours, and the filtrate was then tested for the catalytic power after the prussic acid had evaporated at the ordinary temperature, but no trace of oxygen was now developed after addition of hydrogen peroxid. The $\alpha$-catalase in the residue had in this case also preserved the full catalytic power. It would seem, therefore, that while $\beta$-catalase is easily killed by prussic acid $\alpha$-catalase shows considerable resistance, at least as long as it is present in the undissolved state. In weak alkaline solution the result differs, inasmuch as considerable injury is caused to $\alpha$-catalase by prussic acid.

A regeneration of the activity after evaporation of the prussic acid is only observed with $\beta$-catalase when the amount of prussic acid permitted to act upon it has been very small.

BEHAVIOR OF $\alpha$-CATALASE TOWARD HYDROGEN SULPHID.

Two grams of finely pulverized sweated tobacco were suspended in 500 cc. of water and hydrogen sulphid passed through until complete saturation was obtained. The liquid was allowed to stand for twenty-four hours. The tobacco was then collected on a filter and after being washed well was suspended in 30 cc. of water, and 10 cc. of hydrogen peroxid added. In thirty minutes the volume of oxygen developed was 170 cc., while in the control case, after extracting the tobacco (2 grams) well with cold water, it was 609 cc. This shows

that although hydrogen sulphid injures the $\alpha$-catalase at the ordinary temperature, this injury proceeds but slowly.

Schœnbein reports[1] that plant juices instantly lose their catalytic power upon coming in contact with hydrogen sulphid, but the above test shows that this power is not so easily destroyed, after all.

A second test yielded essentially the same result. In both cases a considerable amount of sulphur was set free, leading to the inference that catalase probably promotes the oxidation of $H_2S$ by the oxygen of the air.

BEHAVIOR TOWARD HYDROXYLAMINE.

One gram of hydrochlorid of hydroxylamine[2] dissolved in a little water was neutralized with sodium carbonate, and the solution diluted to 20 cc. After the addition of 1 gram of sweated tobacco the mixture was allowed to stand for eighteen hours. The filtrate was now found to have completely lost every trace of catalytic power. This was not the case, however, with the insoluble portion, which, after washing and suspending in 20 cc. of water with the addition of 10 cc. hydrogen peroxid, developed 29 cc. oxygen in fifteen minutes. In the same length of time 62 cc. were obtained in the control case.

BEHAVIOR TOWARD PHENYLHYDRAZINE.

A concentrated cold-prepared extract of sweated tobacco[3] was salted out with ammonium sulphate, the precipitate pressed between filter paper, dissolved in a little water, and some phenylhydrazine acetate added. After twenty-four hours a small amount of precipitate was formed, which yielded some oxygen gas with hydrogen peroxid, while the filtrate gave only traces. It therefore seems that $\beta$-catalase forms a still somewhat active compound with phenylhydrazine. This, however, requires further study.

In testing $\alpha$-catalase, a weak alkaline solution was mixed with some phenylhydrazine acetate. After twenty-four hours a precipitate was formed, but the amount was insignificant. The clear filtrate, upon the addition of 5 cc. hydrogen peroxid, in ten minutes yielded 11 cc. oxygen, while in the control case 52 cc. of oxygen were obtained. One would naturally suppose that if ketone or ordinary aldehyde groups were present the enzymic activity would be totally destroyed in a short time.[4]

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[1] Journ. prakt. Chem., 1863, p. 340.

[2] This salt has a strong acid reaction, hence experiments made directly with it are not conclusive. The acid reaction has to be removed, since it alone would suffice to injure or kill the enzym.

[3] Prepared with the addition of 10 per cent alcohol to prevent bacterial development.

[4] Emulsin also preserves its powers after it has been in contact with phenylhydrazine acetate for twenty-four hours. It can be precipitated with alcohol and still exhibit its action on amygdalin.

BEHAVIOR TOWARD ALKALINE SILVER SOLUTION.

A very subtile reagent for aldehyde groups is prepared by adding a few drops of dilute caustic soda to an ammoniacal silver solution which contains only a small excess of ammonia. Such a solution, containing 2 per cent silver oxid, was added to 20 cc. of the $\alpha$-catalase solution above mentioned. After standing twenty-four hours a very small amount of dark sediment was formed, but the solution still had its original degree of catalytic power. A considerable separation of metallic silver and a destruction of the catalytic power would naturally have been expected were ordinary aldehyde groups concerned in the activity.

In a second test freshly precipitated silver oxid was suspended in 40 cc. of a solution of crude $\beta$-catalase (obtained by salting out tobacco extract with sodium sulphate) and the mixture tested after standing at the ordinary temperature for two days. To this and the control solution were added several drops of ether. In testing both solutions at the same time, it was found that while 20 cc. of the control solution, after the addition of 10 cc. hydrogen peroxid, developed 53 cc. of oxygen in two minutes, the filtrate from the silver oxid took three minutes to do the same; hence the injury caused by silver oxid was only moderate.

## GENERAL OCCURRENCE OF $\alpha$-AND $\beta$-CATALASE.

Numerous tests have established beyond a doubt that catalase is of general occurrence in the vegetable kingdom. No living plant or vegetable organ tested was found free from it, some of the plants containing more of the soluble and others more of the insoluble form. Leaves from various plant families showed principally the insoluble catalase, in some cases only slight traces of the soluble kind being noticeable, while in various seeds the soluble kind was found present in larger proportions.

Healthy green tobacco leaves, taken from the greenhouse on December 22, were dried at 40° C. After being ground to a fine powder 2 grams were extracted with 40 grams of water for three hours at the ordinary temperature. The filtrate gave reactions for oxidase and peroxidase, but showed no catalytic power on hydrogen peroxid, and therefore contained no $\beta$-catalase.[1] The well-washed residue, suspended in 20 cc. water, developed, after the addition of 12 cc. hydro-

[1] Traces of $\beta$-catalase may be observed, however, when the green tobacco leaves have not been dried, but are ground and expressed in the fresh state, the clear filtrate being directly tested. It must be borne in mind, however, that the frequent presence of nitrates in the leaves may decrease the action on hydrogen peroxid to a considerable extent, which might lead sometimes to the inference of the presence of only very small quantities of $\beta$-catalase.

gen peroxid, 107.2 cc. oxygen in fifteen minutes, and was relatively rich in $\alpha$-catalase. The stalk of the tobacco plant is about as rich in this enzym as the leaves, but the fine roots contain less. Only one comparative test was made on this point, however. In the flowers (air dry) of the tobacco plant hardly any $\beta$-catalase is found, but considerable $\alpha$-catalase.

Besides Phanerogams from different families, ferns, mosses, liverworts, and higher and lower algæ, as well as fungi, were also tested with positive results. It may be mentioned that vegetable cells die quickly in a 0.5 per cent solution of hydrogen peroxid, while their catalase is much more slowly injured.

Suitable data which would allow the investigator to calculate the absolute weight of catalase from a certain volume of oxygen developed in a given time and at neutral reaction are thus far not known; hence the volumes of oxygen given off by different objects can have only a relative value, serving for purposes of comparison. This is also the reason why these volumes were not reduced to normal pressure and 0° C.[1] The following tests with leaves, fruits, and seeds were carried on at the request of the writer by Mr. D. W. May. Eight grams of the leaves in the fresh state were crushed to a pulp, with the aid of a little sand and water, before the hydrogen peroxid was added, while two grams of the seeds in the air-dried state were finely pulverized, shaken up with 50 cc. of water, and the mixture left in the ice box overnight for extraction. The filtrates were gradually mixed with 5, 10, or even more cubic centimeters of hydrogen peroxid, as the degree of activity in special cases demanded, while the washed residue was suspended in from 50 to 60 cc. water before the hydrogen peroxid was added.

*Cubic centimeters of oxygen developed by different leaves.*

| | 5 minutes. | 10 minutes. | 15 minutes. | 20 minutes. | 25 minutes. |
|---|---|---|---|---|---|
| Magnolia (Magnolia sp.) | 47 | 92 | 129 | 163 | ..... |
| Holly (Ilex sp.) | 50 | 95 | 129 | ..... | ..... |
| Clover[2] (Trifollum repens) | 98 | 129 | 176 | 218 | ..... |
| Cotton (Gossypium herbaceum) | 49 | 102 | 157 | 209 | ..... |
| Rose[2] (Rosa sp.) | 52 | 106 | 156 | 202 | 252 |
| Spruce (Picea sp.) | 56 | 107 | 148 | ..... | ..... |

[1] It may be mentioned, however, that the temperature of the laboratory ranged generally from 16° to 22° C. and the barometric pressure from 746 to 771 mm.

[2] Clear filtrates of the diluted juices of the leaves of rose and clover were also prepared and tested but $\beta$-catalase was absent.

*Cubic centimeters of oxygen developed by various seeds.*

| | | Minutes. | | | |
|---|---|---|---|---|---|
| | | 5. | 10. | 15. | 20. |
| **GRAMINEÆ:** | | | | | |
| Sweet corn (Zea saccharata) | Filtrate... | 99.0 | 150.0 | ..... | 191.0 |
| | Residue .. | 38.0 | 52.0 | 59.0 | ..... |
| Barley (Hordeum sativum) | Filtrate... | 9.0 | 14.0 | 17.0 | ..... |
| | Residue .. | 20.0 | 32.0 | 42.0 | ..... |
| Rye (Secale cereale) | Filtrate... | 8.0 | 11.4 | 14.0 | ..... |
| | Residue .. | 12.5 | 17.0 | 20.0 | ..... |
| Wheat (Triticum sativum) | Filtrate... | 4.4 | 7.0 | 9.6 | ..... |
| | Residue .. | 6.5 | 9.2 | 11.0 | ..... |
| Wheat (Calif.) (Triticum sativum) | Filtrate... | 9.0 | 14.0 | 18.0 | ..... |
| | Residue .. | 13.1 | 20.1 | 24.0 | ..... |
| Millet (Chaetochloa italica) | Filtrate... | 21.0 | 39.0 | 62.0 | 79.0 |
| | Residue .. | 18.0 | 25.0 | 31.0 | 36.0 |
| **CRUCIFERÆ:** | | | | | |
| Black mustard (Brassica nigra) | Filtrate... | 3.0 | 3.0 | ..... | ..... |
| | Residue .. | 9.5 | 12.7 | 14.0 | ..... |
| White mustard (Brassica alba) | Filtrate... | 3.2 | 3.5 | ..... | ..... |
| | Residue .. | 4.8 | 8.0 | 11.0 | ..... |
| Turnip (Brassica rapa) | Filtrate... | 1.0 | 1.7 | ..... | ..... |
| | Residue .. | 98.0 | 121.0 | 125.0 | ..... |
| Radish (Raphanus sativus) | Filtrate... | 2.0 | 2.4 | 2.6 | ..... |
| | Residue .. | 62.0 | 79.0 | 87.0 | ..... |
| Rape (Brassica napus) | Filtrate... | 1.0 | 1.0 | ..... | ..... |
| | Residue .. | 66.0 | 90.0 | 103.0 | ..... |
| **LEGUMINOSÆ:** | | | | | |
| Peas (Pisum sativum) | Filtrate... | 16.0 | 19.0 | 21.0 | ..... |
| | Residue .. | 3.6 | 4.0 | 4.2 | ..... |
| Beans (Phascolus vulgaris) | Filtrate... | 62.0 | 82.0 | 95.0 | ..... |
| | Residue .. | 20.0 | 28.0 | 35.0 | ..... |
| Lentils (Lens esculenta) | Filtrate... | 8.2 | 10.2 | 11.2 | ..... |
| | Residue .. | 18.0 | 24.0 | 26.0 | ..... |
| Lupins (Lupinus luteus) | Filtrate... | 44.0 | 60.0 | 70.0 | ..... |
| | Residue .. | 61.0 | 79.0 | 89.0 | ..... |
| Clover (Trifolium repens) | Filtrate... | 107.0 | 170.0 | 214.0 | ..... |
| | Residue .. | 100.0 | 162.0 | 221.0 | ..... |
| Alfalfa (Medicago sativa) | Filtrate... | 48.0 | 58.0 | 63.0 | ..... |
| | Residue .. | 67.0 | 108.0 | 130.0 | ..... |
| **VARIOUS FATTY SEEDS:** | | | | | |
| Cotton (Gossypium herbaceum) | Filtrate... | 112.0 | 112.5 | ..... | ..... |
| | Residue .. | 75.0 | 101.0 | 103.0 | ..... |
| Flaxseed (Linum usitatissimum) | Filtrate... | 59.0 | 88.0 | 96.0 | ..... |
| | Residue .. | 66.0 | 90.0 | 95.0 | ..... |
| Sunflower (Helianthus annuus) | Filtrate... | 84.0 | 104.0 | 121.0 | ..... |
| | Residue .. | 109.0 | 159.0 | 172.0 | ..... |
| Poppy (Papaver sp.) | Filtrate[1].. | 72.0 | 132*0 | 194.0 | ..... |
| | Residue .. | 92.0 | 150.0 | 203.0 | ..... |
| **MISCELLANEOUS SEEDS:** | | | | | |
| Tobacco (Nicotiana tabacum) | Filtrate... | 50.0 | 70.0 | 81.0 | ..... |
| | Residue .. | 32.0 | 45.0 | 54.0 | ..... |
| Beet (Beta vulgaris) | Filtrate... | 25.0 | 30.0 | 32.0 | ..... |
| | Residue .. | 24.0 | 31.0 | 33.0 | ..... |
| Squash (Cucurbita sp.) | Filtrate... | 79.0 | 91.0 | 96.0 | ..... |
| | Residue .. | 33.0 | 44.0 | 49.0 | ..... |
| Pumpkin (Cucurbita pepo) | Filtrate... | 96.0 | 142.0 | 167.0 | ..... |
| | Residue .. | 64.0 | 88.0 | 96.0 | ..... |
| Peach (Prunus persica) | Filtrate... | 50.0 | 108.0 | 132.0 | ..... |
| | Residue .. | 178.0 | 214.0 | 226.0 | ..... |
| Almonds (Prunus amygdalus) | Filtrate... | 22.0 | 36.0 | 48.0 | ..... |
| | Residue .. | 5.5 | 7.5 | 9.5 | ..... |
| Chestnut (Castanea americana) | Filtrate... | 63.0 | 99.0 | 116.0 | 117.0 |
| | Residue .. | 68.0 | 89.0 | 96.0 | ..... |
| English walnut (Juglans regia) | Filtrate... | 50.0 | 85.0 | 89.0 | 100.0 |
| | Residue .. | 85.0 | 92.0 | 95.0 | ..... |
| Pecan (Hicoria pecan) | Filtrate... | 29.0 | 47.0 | 62.0 | ..... |
| | Residue .. | 88.0 | 103.0 | 103.0 | ..... |
| Filbert (Corylus sp.) | Filtrate... | 48.0 | 73.0 | 85.0 | 92.0 |
| | Residue .. | 44.0 | 66.0 | 80.0 | 88.0 |
| Butternut (Juglans cinerea) | Filtrate... | 15.0 | 29.0 | 38.0 | ..... |
| | Residue .. | 7.0 | 11.0 | 14.0 | ..... |
| Peanut (Arachis hypogea) | Filtrate... | 117.0 | 123.0 | 124.0 | ..... |
| | Residue .. | 72.0 | 97.0 | 110.0 | ..... |
| Peanut hull | Filtrate... | 3.0 | 5.0 | 8.0 | ..... |
| | Residue .. | 6.0 | 10.0 | 12.0 | ..... |

[1] This filtrate was not perfectly clear.

*Cubic centimeters of oxygen developed by various fruits, etc.*

| | | Minutes. | | | |
|---|---|---|---|---|---|
| | | 5. | 10. | 15. | 20. |
| Orange (Citrus aurantium sinensis) | Filtrate | 1.5 | 1.8 | ..... | ..... |
| | Residue | 2.5 | 2.5 | ..... | ..... |
| Orange II | Filtrate | 2.0 | 4.0 | ..... | ..... |
| | Residue | 3.0 | 3.2 | ..... | ..... |
| Orange peel | Filtrate | 1.8 | 2.0 | ..... | ..... |
| | Residue | 4.0 | 7.0 | 9.0 | ..... |
| Lemon[1] (Citrus medica limon) | Filtrate | 1.0 | 1.5 | ..... | ..... |
| | Residue | .6 | .8 | ..... | ..... |
| Lemon peel | Filtrate | 1.0 | 1.2 | ..... | ..... |
| | Residue | 3.2 | 4.5 | ..... | ..... |
| Banana (Musa sapientum) | Filtrate | 3.0 | 3.0 | ..... | ..... |
| | Residue | 6.5 | 10.0 | 13.0 | 14.0 |
| Banana peel | Filtrate | 5.0 | 7.5 | 10.5 | ..... |
| | Residue | 40.0 | 72.0 | 87.0 | 96.0 |
| Apple, sour (Pyrus malus) | Filtrate | 4.0 | 4.2 | ..... | ..... |
| | Residue | 3.0 | 3.0 | ..... | ..... |
| Apple, subacid | Filtrate | 1.0 | 1.6 | ..... | ..... |
| | Residue | 2.2 | 3.2 | 3.6 | ..... |
| Apple peel | Filtrate | 3.0 | 3.0 | ..... | ..... |
| | Residue | 3.0 | 5.0 | ..... | ..... |
| Apple peel, subacid | Filtrate | 2.8 | 3.8 | 4.8 | ..... |
| | Residue | 16.0 | 26.0 | 34.0 | ..... |
| Apple seed[2] | Filtrate | 119.0 | 180.0 | 227.0 | ..... |
| | Residue | 110.0 | 163.0 | 223.0 | ..... |
| Pear (Pyrus communis) | Filtrate | 5.5 | 7.2 | 9.4 | ..... |
| | Residue | 20.0 | 30.0 | 35.0 | ..... |
| Pear peel | Filtrate | 22.0 | 33.0 | 42.0 | 45.0 |
| | Residue | 62.0 | 91.0 | 101.0 | 104.0 |
| Date (Phœnix dactylifera) | Filtrate | 4.0 | 7.0 | 8.0 | ..... |
| | Residue | 10.5 | 17.5 | 23.0 | ..... |
| Strawberries, sour (Fragaria chiloensis) | Filtrate | .5 | 1.0 | ..... | ..... |
| | Residue | .5 | 1.0 | ..... | ..... |
| Strawberries, neutralized | Filtrate | 6.0 | 7.5 | ..... | ..... |
| | Residue | 2.0 | 3.5 | ..... | ..... |
| Onion, bulb (Allium cepa) | Filtrate | 3.0 | 5.0 | 6.5 | ..... |
| | Residue | 21.0 | 37.0 | 62.0 | ..... |
| Onion leaves | Filtrate | 76.0 | 97.0 | 110.0 | ..... |
| | Residue | 91.0 | 140.0 | 189.0 | ..... |
| Potato flesh (Solanum tuberosum) | Filtrate | 56.0 | 82.0 | 92.0 | 98.0 |
| | Residue | 52.0 | 71.0 | 80.0 | 85.0 |
| Potato peel | Filtrate | 60.0 | 82.0 | 93.0 | 98.0 |
| | Residue | 75.0 | 94.0 | 101.0 | 102.0 |

[1] The lemon juice neutralized by carbonate of soda yielded 5 cc. oxygen in five minutes.
[2] The filtrate from apple seed developed 552 cc. oxygen in forty-five minutes, the residue 379 cc. in thirty minutes.

We learn from these determinations that the flesh of the fruits when of an acid character is poor in catalase and that at the same time the seeds may be very rich in it. Compare, for instance, the above data for apple seed and apple flesh. It is true that a better result is obtained after neutralization of the acid, but even in this case the catalytic power appears small. Compare, also, the data for strawberry and lemon. Evidently the accumulation of acid kills the enzym. We notice further a relatively large amount in the fatty seeds, but in starchy seeds only the sweet corn and chestnut are noticeably rich in catalase. Relatively a very large content of $\beta$-catalase is observed with seeds of poppy and clover. Turnip, radish, and rape seed, while rich in $\alpha$-catalase, are exceedingly poor in $\beta$-catalase. During germination the total catalase is very much increased, as observed with barley shoots about 5 cm. long. Twenty grains yielded in twenty minutes 30 cc. of oxygen, while twenty shoots from the same lot yielded fully 130 cc.

In fungi the amount of catalase is relatively very large. Spores of *Penicillium glaucum* were sown in one liter of a sterilized aqueous solution of the following:

| | Per cent. |
|---|---|
| Peptone | 0.1 |
| Glucose | .5 |
| Malic acid | .2 |
| Dipotassium phosphate | .1 |
| Magnesium sulphate | .01 |

After four weeks a large mass of mycelium with spores was developed, which was filtered off. In the clear yellowish filtrate, which now showed a neutral reaction, a considerable reaction for $\beta$-catalase was obtained, but none for either oxidase or peroxidase.[1] Of this filtrate three portions of 50 cc. each were taken. The first was mixed directly with 10 cc. of hydrogen peroxid; the second portion only after heating for two minutes at 75° C. and quickly cooling; the third portion after heating to 87° for one minute and allowing to cool slowly. The volume of oxygen developed in fifteen minutes from the first portion was 78 cc., from the second portion only 14.8 cc., while from the third portion no oxygen at all was developed. The washed mycelium, together with the spores, was now left for one hour in 80 per cent alcohol in order to kill the mycelium, which was then pressed gently between filter paper, dried at 40° C., and finely pulverized. Of this product 0.5 gram was again washed well with water, in order to remove all $\beta$-catalase, and then suspended in 20 cc. water. Hydrogen peroxid in portions of 10 cc. was now gradually added. The sudden start and sudden stop of the development of oxygen gas was very striking and evidently indicated the presence of a great deal or of a very energetic kind of catalase. When the process had slowed down considerably further addition was stopped. In the short time of forty-one minutes fully 800 cc. of oxygen were developed[2] from 90 cc. of hydrogen peroxid added. It was probably the $\alpha$-catalase of the mycelium only and not that of the spores of the fungus that caused this considerable development, since the membranes of the latter are impregnated by a fatty substance that admits aqueous solutions to the interior with considerable difficulty.[3]

Another fungus tested was *Pleurotus sapidus*, which proved very rich in $\beta$-catalase but less rich in $\alpha$-catalase. Conidia of a Uredo also showed a very powerful action.

A test for catalase in bakers' yeast yielded the following result: A portion was divided into three equal parts, one part being dried at

[1] A slight blue coloration that set in after half an hour's standing in the test for oxidase (not peroxidase) can hardly be considered as a decisive test.

[2] Barometric pressure 771 mm.; temperature 22° C.

[3] That the accumulation of $\beta$-catalase in a liquid is not inimical to bacterial growth was proven with the mold culture filtrates.

110° C. to determine the dry matter, which was found to be 1.851 grams; another portion, suspended in 25 cc. of water, after the addition of 10 cc. of hydrogen peroxid developed 82 cc. of oxygen in thirty minutes; the third part was left with 100 cc. of a 10 per cent glucose solution for twenty-four hours and, after filtering the fermenting liquid, the filtrate and residue were tested separately. The filtrate gave no reaction with hydrogen peroxid; the residue treated as above gave 108 cc. of oxygen in thirty minutes. This sample of yeast contained no oxidase and but a trace of peroxidase.

Another test was made with fresh beer yeast, the yeast being free from any trace of oxidase and containing only a faint trace of peroxidase. A portion of the yeast was suspended in 100 cc. of water and with frequent shakings the mixture was divided into two equal parts, one part serving for the determination of the dry matter, which was found to be 0.540 gram. The other part was left with 3 cc. of chloroform for twenty-four hours in order that the cells might be killed and consequently give up their enzyms to the water more easily, thus making it possible to determine whether there was any soluble catalase present. This was found to be the case. The clear filtrate gave, upon the gradual addition of 15 cc. of hydrogen peroxid, 117 cc. of oxygen in thirty minutes. The killed yeast itself, however, after washing gave 452 cc. of oxygen in fifteen minutes. This hardly leaves any doubt but that the amount of $\alpha$-catalase here is larger than the amount of $\beta$-catalase. It is noticeable also that the fresh beer yeast is richer in total catalase than bakers' yeast.

Various bacteria also produce considerable catalase,[1] *Bacillus pyocyaneus*, for example; but the amount depends to some extent upon the conditions of nutrition. In a nutrient fluid containing 0.5 per cent peptone and 1 per cent glycerol or cane sugar as organic materials there was much less catalase produced than in a solution containing 1 per cent glycerol, 0.2 per cent tyrosine, and 0.2 per cent sodium acetate, but no peptone.

In the animal kingdom catalase is also of general occurrence. The aqueous extracts of spleen, pancreas, liver, kidney, brain, muscles, and also the blood serum show the power of catalyzing hydrogen peroxid, but certain secretions, as, for example, the urine, lack it. Infusoria, insects, worms, and mollusks were examined also with positive results.

The luminous parts of a lightning beetle do not contain a markedly larger proportion of catalase than other parts of this insect. Different parts of about equal size were crushed with about 10 cc.

[1] Other oxidizing enzyms—oxidase and peroxidase—do not appear to be produced by many bacteria. Cultures of *B. subtilis* and *B. pyocyaneus* did not show them, but according to Roux (Comptes Rend., vol. 128, p. 212, 1899), *B. coli* can produce one of these.

water, and after transferring into an Erlenmeyer flask, 5 cc. hydrogen peroxid were added (rendered previously slightly alkaline). The time necessary to produce 20 cc. and 40 cc. oxygen was then noted. The results were:

| Oxygen. | With head. | With upper abdomen. | With luminous parts. |
|---|---|---|---|
| | *Minutes.* | *Minutes.* | *Minutes.* |
| 20 cc | 1¼ | 1¾ | 1¼ |
| 40 cc | 5¾ | 7½ | 5¼ |

A small beetle of about the size of the head of the lightning beetle produced 40 cc. oxygen in six and one-fourth minutes, while a medium-sized *Carabus*, 0.618 gram in weight, after being crushed with 20 cc. water, produced, upon the gradual addition of 20 cc. hydrogen peroxid, 168 cc. oxygen in four minutes, corresponding to the decomposition of nearly 0.5 gram pure anhydrous hydrogen peroxid.

The extracts[1] of animal organs yield, on saturation with ammonium sulphate, precipitates which, after drying at the ordinary temperature, are only partly soluble again in water. However, not only the soluble portion, but also that which has become insoluble, shows catalytic power. Two-tenths of a gram of the insoluble part of a crude catalase preparation from calf's spleen, when suspended in 20 cc. water, yielded, upon addition of 5 cc. hydrogen peroxid, 29.2 cc. oxygen in twenty minutes. Hence this product contains relatively little of the active principle. An aqueous extract of beef muscles has a high degree of catalytic power, and even after it is heated for one moment to 62° C. and the coagulated albumen is removed the clear filtrate has still a powerful action on hydrogen peroxid, while the coagulum itself gives merely a faint trace of action, showing that it absorbed only traces of catalase. Finely chopped beef extracted for fifteen minutes with twice its weight of water at 40° C. yielded a reddish filtrate of weak acid reaction, of which 20 cc. decomposed 5 cc. of a 3 per cent hydrogen peroxid preparation almost completely in one minute. When rendered slightly alkaline the same amount of filtrate produced, upon addition of 20 cc. hydrogen peroxid, fully 163 cc. oxygen gas in but two minutes.

The presence of $\alpha$-catalase as well as $\beta$-catalase in the pancreatic gland becomes probable from the fact that the pulp shows considerable catalytic power even after repeated extraction with chloroform water. A 1 per cent solution of sodium carbonate at the ordinary temperature, however, extracts the insoluble portion of catalase but slowly, and besides transforms a part of it into $\beta$-catalase by its prolonged influence. The hen's egg is an object poor in catalase. Ten cc. of the white of an egg, upon mixture with 5 cc. hydrogen peroxid, yielded

[1] These extracts were prepared by the digestion of the finely chopped organs with water at 40° to 50° C. for a short time and filtering.

only 21 cc. of oxygen in fifteen minutes, and the entire yolk yielded only 1 cc.

Milk sometimes contains only traces of catalase. In one case 20 cc. of fresh cow's milk gave, upon the addition of 10 cc. hydrogen peroxid, only 2.4 cc. oxygen in fifteen minutes.[1] In another instance 20 cc. of fresh milk yielded, after the addition of 15 cc. hydrogen peroxid, 9.2 cc. oxygen in the same length of time.[2]

Some observations made by Spitzer[3] with regard to the amounts of oxygen produced by various organs may be added here:

| Oxygen developed in— | Dog. | | | | Cattle. | Frog. |
|---|---|---|---|---|---|---|
| | Blood (1 gram). | Liver (1 gram). | Brain (2 grms.). | Muscles (2 grms.). | Pancreas (1 gram). | Ovaries (2 grms.). |
| | cc. | cc. | cc. | cc. | cc. | cc. |
| 4 minutes | 85 | 65 | 30.8 | 22 | 71 | 24 |
| 13 minutes | | 76 | 56 | 54 | 82 | 48 |

## IS CATALASE AN OXIDIZING ENZYM?

The simple fact that catalase energetically decomposes hydrogen peroxid would not in itself justify the inference that catalase is also an oxidizing enzym. Such a deduction has, however, some probability, since we find this catalytic property together with the power of inducing oxidations in one other substance, viz, platinum black. But platinum black furthermore shows the chief characteristic of the ordinary oxidase—that of causing, even in the absence of hydrogen peroxid, a blue reaction with guaiac, which reaction is not obtained with catalase. With platinum black even reducing actions are known,[4] the writer having years ago shown that nitrates are reduced to ammonia by glucose in aqueous solution upon the addition of some very active platinum black.[5] In this process the oxygen of the nitrates is thrown upon the sugar, which is thus converted into acids, while hydrogen from the sugar migrates to the nitrogen of the nitrates, yielding ammonia. This interesting process, which demonstrates that an agency causing oxidations can under other circumstances also cause reductions, seems to have remained unknown to some recent writers, to judge from their peculiar discussions of the reducing actions in the living cells.

[1] Since catalase and other oxidases are not constant concomitants of milk, it might be of interest to compare, in this regard, milk from healthy with that from diseased animals.

[2] The so-called test of Storch to distinguish boiled from unboiled milk has nothing to do with catalase.

[3] Pflüger's Archiv, vol. 67 (1897).

[4] Berichte der Deutschen Chemischen Gesellschaft, Vol. XXIII, p. 675 (1890).

[5] The decrease of the nitrate content during the sweating process of tobacco and the formation of nitrite (and probably of ammonia) thereby may be due to an analogous action of catalase. A short contact, however, does not suffice to accomplish such a change, as a special test showed.

In how many particulars, however, the behavior of platinum black is again encountered in catalase will need to be determined by special investigations. Some authors hold the oxidases to be transferrers of oxygen, but in reality they are transferrers of chemical energy by which certain other compounds are enabled to take up the molecular oxygen directly, which they could otherwise do only at a high temperature. Spitzer ascribes to the iron organically bound in certain nucleo-proteids the property of inducing oxidations. The ordinary oxidase and peroxidase, however, as well as $\beta$-catalase, do not possess the general characteristics of nucleo-proteids, but those of albumoses.

The action of oxidizing enzyms in animals has been investigated by a number of authors. It has been found that a pulp made from various animal organs, or extracts prepared therefrom, can oxidize salicylic aldehyde, benzaldehyde, and formaldehyde to their corresponding acids. Methyl alcohol can be oxidized to formic acid, benzyl alcohol to benzoic acid, and the oxidation of acetone and uric acid has also been observed. Various color reactions[1] caused by oxidation, as the formation of indophenol, Bindschedler's green, and totuylene-blue,[2] are also, according to Spitzer, induced by the animal oxidases. Of inorganic materials the oxidation of arsenious to arsenic acid by animal juices was observed by Binz.

It appears that several oxidizing enzyms exist in animals. Pohl prepared extracts which were capable of oxidizing aldehydes but incapable of giving the indophenol reaction. Jacoby observed the destruction of uric acid by dog's liver, but not by calf's liver. We encounter further contradictory statements, especially in regard to the oxidation of glucose and arabinose by the expressed juices of liver and pancreas. Jacoby found the amount of arabinose thus oxidized to be very small.[3] W. Spitzer and others have observed the destruction of a small amount of glucose by blood drawn from animals and by various extracts of animal organs.[4] This so-called glycolysis was ascribed to an oxidizing enzym which, according to Spitzer, gives a blue reaction

[1] These color reactions are best obtained by moistening paper with the reagents and bringing it in contact with the animal pulp.

[2] The colored compounds of Lauth can not, however, be formed by oxidases (Spitzer).

[3] This author further observed that the animal oxidase which easily oxidizes salicylic aldehyde to salicylic acid, is not destroyed at 70° C., and that small quantities of chloroform, or a solution of 0.1 per cent sodium hydrate, stimulate its action, while 1 per cent sodium carbonate, or 0.3 per cent sodium hydrate, prevent it.

[4] Pflüger's Archiv, vol. 60, p. 303 (1895). As examples he mentions that 10 cc. dog's blood can destroy in one hour, at 40° C., 20 milligrams of glucose (determined by titration); 25 cc. defibrinated dog's blood oxidized (completely?) at 39° C., 0.1 gram of glucose in twenty-four hours. The serum is not active; the cellular elements contain the active principle (Lépine, Spitzer). Addition of hydrogen peroxid did not promote the process of destruction, not even upon further addition of palladium, which produced nascent oxygen from the hydrogen peroxid.

with guaiac on addition of hydrogen peroxid, and also shows at the same time catalytic action on hydrogen peroxid. This opinion, however, had already been doubted by Jacoby, who assumes not only one but several oxidizing enzyms in the animal, and also holds that the agency oxidizing the sugar is different from that which oxidizes salicylic aldehyde to salicylic acid.[1]

Quite recently F. Umber[2] has asserted that the destruction of sugar by an extract of the pancreas gland is merely due to microbes, since it is not observed when antiseptic measures are resorted to.

The inability of $\alpha$- and $\beta$-catalase to produce a blue reaction with guaiac solution appears at first sight to be decisive against the assumption that these enzyms can bring on any oxidation; but this inference is not justifiable, since the action of the oxidizing enzyms is sometimes quite specific; that is, they act only on a certain group of bodies of a distinct chemical character or on compounds in which not only a certain degree of lability, but also a configuration, is found that coincides in a certain measure with that of the oxidizing enzym. Grüss has recently observed an oxidizing enzym in barley grains which has no reaction on guaiac, but yields a violet color with tetramethylparaphenylendiamine. He calls it spermase.[3]

The indophenol reaction also can not be produced by catalase. This was tried with a preparation from sweated tobacco and with one obtained by salting out the filtrate of a culture of *Penicillium* by ammonium sulphate. A trace of hydrogen peroxid in the control case sufficed to produce this blue color in the mixture of paraphenylendiamine and $\alpha$-naphthol in presence of sodium carbonate, even in the absence of oxidizing enzyms.

A characteristic oxidation by catalase, however, is produced with hydroquinone, the odor of quinone being developed within a very short time. This has been tried with $\beta$-catalase salted out from the juice of potatoes, with extract of poppy seed, with a concentrated extract of sweated tobacco, and, further, with tobacco that had been well extracted with water containing chloroform. This well-washed tobacco, containing a considerable amount of $\alpha$-catalase, gave, after being moistened with a dilute solution of hydroquinone and standing fifteen minutes, the characteristic quinone odor, which after

[1] Virchow's Archiv, vol. 157, p. 235 (1899).

[2] Zeitschrift für Klinische Medicin, vol. 39, p. 13 (1900).

[3] Sometimes the reaction of the medium to be tested has to be carefully observed, since certain color reactions, as, for example, the indophenol reaction, succeed only in weak alkaline solution. Sometimes certain compounds may also be present which interfere with the production of the reaction. Thus, Epstein observed that the action of the oxidase contained in fresh juice of beets is prevented by the presence of prussic acid, and is restored when this is expelled by a current of air. This is also a decisive proof of the enzymatic nature of the oxidizing phenomena in fresh beet juice. (Archiv für Hygiene, vol. 36, p. 140.)

twenty-four hours became very strong. The same moist tobacco was heated in a closed vessel to 95° C. for ten minutes and then moistened with the same solution, but no trace of the quinone odor could be perceived, even after twenty-four hours. The same negative behavior was observed with tobacco cured with artificial heat at a higher temperature and therefore containing no catalase (flue-cured bright-yellow Virginia tobacco), no trace of the odor being produced.

The sweated tobacco which was used in the tests with hydroquinone was free from oxidase and peroxidase and did not contain any other known enzym;[1] it therefore follows that $\alpha$- and $\beta$-catalase belong to the class of oxidizing enzyms.

The smell of quinone produced by the action of animal catalase upon hydroquinone is less marked, perhaps on account of the presence of too large a proportion of impurities of a protein nature. But this oxidation can be observed well when to a concentrated extract of beef, made at the ordinary temperature, 1 per cent of hydroquinone is added and the mixture is left for several days in a large flask plugged with cotton. The hydroquinone produces a precipitate and also a gradual and moderate darkening of the mixture. It furthermore prevents, in that concentration, bacterial development. When after several days a little oxalic acid is added, a very marked odor of quinone is developed, becoming much stronger on heating.

While certain oxidases can oxidize very dilute eugenol to vanillin, catalase seems incapable of accomplishing this; at least no odor of vanillin was noticeable after one day. Nor is ethyl alcohol oxidized by it either to aldehyde or to acetic acid, and cyanin is not decolorized by it, although this compound is easily destroyed by other oxidizing agents, as, for example, hydrogen peroxid. Saligenin and indigo carmin are not attacked by it, at least not in neutral solution.

Other tests were made to ascertain whether carbonic acid would be produced from various organic compounds by the action of $\alpha$-catalase. Sweated tobacco, rich in $\alpha$-catalase, was well extracted with chloroform water at the ordinary temperature, pressed, and an amount corresponding to from 35 to 40 grams of dry matter put in a flask, after being moistened with solutions of the organic substances to be tested, and heated to from 55° to 60° C. in a current of air, which had passed through a solutionof caustic potash and then through a flask containing chloroform. For absorption of the carbonic acid a solution of barium hydrate containing 0.62 per cent of BaO was used. Each test lasted one hour. Control tests were also made, since not only the absorption of carbonic acid from the air by the tobacco before it was placed in the flask, but

[1] It is scarcely necessary to state that the common hydrolyzing enzyms—diastase, emulsin, papain, etc.—have not the power of oxidizing hydroquinone to quinone. The writer has especially assured himself on this point.

also the oxidation of certain organic materials contained in the leaves, was possible.[1]

It was found that of the 25 cc. of baryta water applied in the two control cases there were neutralized 3.1 and 3.4 cc., respectively. The other results were as follows:

| Compound. | Concentration. | Baryta water neutralized. |
|---|---|---|
| | *Per cent.* | cc. |
| Sodium malate | 6 | 3.5 |
| Sodium tartrate | 6 | 5.0 |
| Sodium citrate | 6 | 9.1 |
| Tyrosine | 1 | 4.0 |
| Nicotine sulphate | 1 | 3.5 |
| Soap | 10 | 3.5 |
| Glucose | 20 | 6.2 |

During the one hour the test lasted no distinct traces of ammonia were produced either from tyrosine or nicotine. These compounds might, however, show less resistance under the influence of other oxidation processes of a considerable activity as, for instance, in the fermenting of the tobacco piles. The amount of carbonic acid produced in this short time was also but small, and may represent a mere by-product of partial oxidations. Some oxidation in the above cases can only be assumed for glucose and citric acid, since the other numbers differ too little from those of the control case.

Another special test showed that an aqueous solution of 0.5 per cent glucose, in presence of 1 per cent phenol as an antiseptic, is not changed by $\beta$-catalase at the ordinary temperature within a fortnight. The solution was kept in a large closed flask in contact with much air, and was repeatedly titrated with Fehling's reagent. The result may differ, however, when the mixture is exposed to the air on a porous surface and in presence of an alkaline reaction.

## THE PHYSIOLOGICAL IMPORTANCE OF CATALASE.

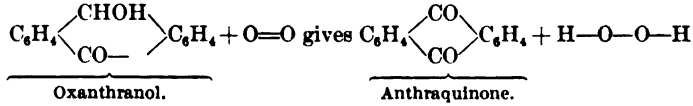
There does not exist a group of organisms or any organ or even a single vegetable or animal cell that does not contain some catalase, as far as the observations of the writer go. This general occurrence of catalase in the organized world can not be accidental and must have a certain significance. Since the destruction of hydrogen peroxid is the most characteristic property of catalase, can this property be of physiological value? Is there any production of hydrogen peroxid in the living cells, and, if so, is the destruction of this product of advantage to the cells? The catalase of the cells would energetically destroy any trace of this compound immediately after its formation (see also

[1] By the previous extraction with water, fatty matter, nucleo-proteids, and a portion of the coloring matter could not, of course, be removed.

p. 17.) The possibility of the production of hydrogen peroxid in the living cells while the energetic oxidation representing the respiration process is going on, can not be denied; it is, in fact, very probable. Recent investigations have shown beyond a doubt that labil hydrogen atoms in an organic compound can form hydrogen peroxid on coming into contact with free oxygen. When it happens that the main organic complex is otherwise not readily oxidized, and especially is not easily changed further by the hydrogen peroxid formed, the amount of the latter produced can be determined quantitatively. Thus it can be shown that this amount corresponds to the amount of the labil hydrogen atoms which have separated from the organic compound to combine with molecular oxygen. Such a compound is phenylhydroxylamine, studied by Eugen Bamberger.[1] It has a relatively stable atomic structure, the two unstable atoms being the two hydrogen atoms in the hydroxylamine group, which are inclined to combine directly with one molecule of oxygen when exposed to the air in aqueous solution.

$$\underbrace{C_6H_5NHOH}_{\text{Phenylhydroxylamine.}} + \underbrace{O{=}O}_{\text{Molecular oxygen.}} \text{ gives } \underbrace{C_6H_5NO}_{\text{Nitrosobenzene.}^2} + \underbrace{H{-}O{-}O{-}H}_{\text{Hydrogen peroxid.}}$$

In presence of sodium hydrate the hydrogen peroxid formed is rapidly consumed again, the nitrosobenzene being thereby oxidized to nitrobenzene. Hence the primary formation of hydrogen peroxid in this latter case escapes notice, which also happens in numerous other instances of autoxidation. Cases exist, however, where even in presence of sodium hydrate the hydrogen peroxid remains unchanged, as shown by W. Manchot.[3] Oxanthranol dissolved in alkalies forms a red solution which in contact with air is rapidly decolorized and separates white anthraquinone, while at the same time hydrogen peroxid is produced.




It was found by that author that for one molecule of anthraquinone one molecule of hydrogen peroxid was produced, which confirms the correctness of this equation. Quite in analogy is the transformation of dihydrophenanthrenquinone to phenanthrenquinone, that of hydrochrysoquinone and hydroretenquinone to their respective ketones, and that of hydrazotriazol to azotriazol.

[1] Berichte der Deutschen Chemischen Gesellschaft, vol. 33, p. 113 (1900).

[2] The nitrosobenzene thus primarily formed is acted upon by still unchanged molecules of phenylhydroxylamine and forms azoxybenzene. Three grams of phenylhydroxylamine in 40 cc. water yielded, after treatment with a current of air for seventy hours, 2.5 grams azoxybenzene and 0.398 gram hydrogen peroxid, which corresponds to 92.5 per cent of the theoretical yield.

[3] Ueber freiwillige Oxydation, Leipzig, Veit & Co., 1900.

Hence the view of Traube that *nascent* hydrogen atoms can reduce molecular oxygen to hydrogen peroxid can also be extended to *labil* hydrogen atoms.

The transformation of molecular oxygen into hydrogen peroxid is considered as an activifying of oxygen. In analogy with the formation of hydrogen peroxid the peroxids of organic complexes also may be formed in certain processes of autoxidation, as Engler[1] has recently shown for pinen, amylen, hexylen, styrol, cyclopentadiën, and diallylether. Benzaldehyde yields by autoxidation, according to Baeyer,[2] primarily benzoylated hydrogen peroxid, $C_6H_5—CO—O—O—H$, which easily transfers 1 atom of oxygen upon another molecule of benzaldehyde, or upon some other easily oxidizable material, and thereby becomes benzoic acid. This would, however, not yet justify an attempt to extend the analogy also upon the oxidations caused by the living protoplasm, since it would involve a continuous oxidation of the protoplasm itself and lead to an early death of the cells before reconstruction of the injured parts would become possible. Nevertheless the proteids composing the living matter betray an aldehyde nature by the toxicological behavior of the living matter.[3]

The oxidations in the living protoplasm have often been ascribed to an activified oxygen, and doubtless many chemists would feel inclined to assume the formation of hydrogen peroxid in order to account for oxidations of which common oxygen seems incapable. But it must be considered that the great lability of the proteids of the living protoplasm—in other words, the accumulation of kinetic chemical energy in them—is here a more important factor than the natural tendency of common oxygen or hydrogen peroxid to cause oxidation. It is further a fact that hydrogen peroxid can not be utilized by the living protoplasm as an oxidizer, since the active atomic groups in the proteids of the living matter would be oxidized by it instead of the thermogens stored up in the cells for combustion, and injury or death would result; indeed the highly poisonous character of hydrogen peroxid is well known.[4] Therefore, since the oxidation in the respiration process would take a detrimental turn if hydrogen peroxid accumulated as a by-product, the rôle of the catalase may possibly be explained. It would destroy every trace of this poisonous substance as quickly as it were formed and would thus afford an important protection. The

[1] Berichte der Deutschen Chemischen Gesellschaft, vol. 33, p. 1103.

[2] Ibid., p. 1582.

[3] These points are fully discussed in chapter 12 of the treatise of the writer, Die chemische Energie der lebenden Zellen, Munich, 1899, E. Wolff, publisher.

[4] In a dilution of 1: 200 hydrogen peroxid kills cholera bacilli in three minutes; of 1:15,000 it impedes development of typhoid bacilli; of 1:10,000 it kills infusoria in from fifteen to thirty-six minutes; and in one of 1:1,000 algæ are killed in a short time. Intravenous injections kill mammals by stopping respiration.

oxygen set free by this destructive operation could at once be utilized again for the continuance of the respiration process.[1]

It may be asked what function the catalase performs in fermenting yeast and anaërobic microbes, since in these there is no normal respiration process and hence no occasion for the formation of hydrogen peroxid by autoxidation.[2] Catalase must then have still another function, and the writer is inclined to assume for it the faculty also of loosening chemical affinities in certain compounds to such a degree that the protoplasm itself can more easily split them, or, when oxygen has access, can more easily oxidize them. In other words, catalase might represent an aid for fermentative as well as as for respirative phenomena. In the case of the yeast it may be of importance for the action of Buchner's zymase. The amount of catalase in yeast is relatively large (see p. 35), and the expressed juice of yeast is also rich in it. Catalase may also be capable of accomplishing certain reducing processes, since platinum black can also induce reductions as well as oxidations (see above, p. 37). An enzym with a reducing action was recently observed by Abelous and Gérard in the aqueous extract of the horse kidney. It is capable of reducing nitrates to nitrites, and nitrobenzene to aniline.[3]

Since catalase is of universal occurrence in the organized world, and is capable of destroying every trace of hydrogen peroxid as soon as it is formed, it is quite impossible that the latter product could ever be found in living cells. The assertions, therefore, of Clermont, Wurster, Bach, and E. Baumann to the contrary have lost every trace of justification. Direct tests by Bokorny, Pfeffer, Cho, and others, have proved the incorrectness of this assumption.[4] It is evident, further, that Reinke's hypothesis of the respiration process,[5] which assumes the formation of hydrogen peroxid as a necessary intermediate step to enable the combustions to take place in the protoplasm, must be abandoned. The protoplasm would hardly prepare a special enzym

[1] Some authors go so far as to ascribe the entire respiration process to the activity of certain enzyms. This view is certainly incorrect; otherwise the oxidations characteristic of the respiration process should continue qualitatively and quantitatively, after heating cells to their death point (40°–50°C).

[2] Among the obligate anaërobic microbes the bacillus of blackleg was tested and also found to contain catalase.

[3] Académie des Sciences, meeting of December 11, 1899.

[4] It may also be mentioned that Schoenbein's assertion of the occurrence of hydrogen peroxid in the violet fluorspar of Wölsendorf has been refuted, since the writer demonstrated long ago that Schoenbein's results are not due to the presence of that supposed "antozon," or to hydrogen peroxid, but to traces of free fluorin, probably formed by the gradual dissociation of small quantities of a superfluorid of cerium. The sentence on p. 113, Vol. XIII, of the "Handwörterbuch" relating to Schoenbein's observations should therefore be corrected.

[5] Botanische Zeitung, 1883, Nos. 5 and 6.

that would destroy with great vigor and promptness a product necessary for its respiration.

The protoplasm represents a most complicated machine, built up of easily changeable proteids. This easy change to comparatively stable forms, in the process of dying, implies a loss of the labil atomic groups by atomic migration in the molecules, and a loss of kinetic chemical energy.[1] The atoms of the labil groups are in continuous motion, representing a charge with kinetic chemical energy. This energy is transferred by the protoplasm to the thermogens, principally sugar and fat (lecithin), which at the ordinary temperature are not at all disposed to oxidize themselves directly on contact with air. By contact with the living protoplasm, however, they become capable of thus oxidizing themselves, since the protoplasm imparts to their atoms such a state of motion that their affinities are loosened and they can take up oxygen from the air without the oxygen being previously activified. This splitting of the oxygen molecules and the combining of the oxygen atoms with the atoms in sugar and fat proceeds at one and the same moment; but at the same time certain labilized activified hydrogen atoms of the thermogens can combine with still entire molecules of oxygen, thus forming hydrogen peroxid as a by-product, as previously mentioned.

The heat produced by the combustion of the thermogens is again turned in a certain measure by the living protoplasm into chemical energy, since the heat energy instigates the atoms of the labil groups to much more intense oscillations than is the case with the more stable atoms. The easy transformation of heat energy into chemical energy is known. The former represents motions of molecules and atoms, the latter an atomic motion which consists of oscillations of a greater amplitude than the motions induced by heat energy. This can be inferred from the fact that, other things being equal, chemical energy is capable of loosening affinities in molecules much more readily than heat energy can at a moderate temperature.

When the thermogens are consumed in the cell without a fresh supply being available, the labil proteids of the living protoplasm themselves take up oxygen. Thus by their partial oxidation a disturbance is produced which may, at a certain stage, lead to the total collapse of the protoplasm with a loss of all the labil groups. This is the death of the cells by starvation.

When, however, thermogens are present but the oxygen is withheld, the activified molecules of sugar undergo other changes, brought on by the far-reaching loosening of affinities, and lactic acid, alcohol, or fat result, accompanied by a simultaneous production of

[1] This energy is perceptible as heat in the dying of the muscular tissues of animals—the so-called postmortem rise of temperature.

carbonic acid from destroyed sugar molecules. This process, which in most cases is of but short duration and is terminated by the early death of the cells by suffocation, is known under the name of "intramolecular respiration." The recent important observations of Eugen Bamberger furnish an interesting chemical analogy to ordinary and intramolecular respiration. He found that $\beta$-phenylhydroxylamine not only oxidizes itself readily on contact with air and induces oxidation of other compounds, as indigo-carmine, but can also, in the presence of a little alkali and the absence of air, change itself to aniline and nitrosobenzene, which represents on the one side a reduction and on the other an oxidation, in full analogy to the changes in intramolecular respiration.

The development of oxygen by the action of catalase upon hydrogen peroxid recalls another instance of development of oxygen; it is the assimilation of carbon. Here the oxygen developed is generally assumed to be derived directly from carbonic acid, as expressed by the following equation:

$$\underbrace{O{=}C{<}^{OH}_{OH}}_{\text{Carbonic acid.}} \text{ becomes } \underbrace{O{=}C{<}^{H}_{H}}_{\text{Formic aldehyde.}} + \underbrace{O_2}_{\text{Molecular oxygen.}}$$

An ingenious hypothesis of Erlenmeyer[1] tries, however, to explain this separation of oxygen by a previous formation of hydrogen peroxid and assumes formic acid to be the first organic product of the assimilation process.

$$O{=}C{<}^{OH}_{OH} + \begin{matrix} H \\ | \\ OH \end{matrix} \text{ becomes } \underbrace{O{=}C{<}^{OH}_{H}}_{\text{Formic acid.}} \cdot \underbrace{HO-OH}_{\text{Hydrogen peroxid.}}$$

$$\begin{matrix} HO{-}O \\ HO{-}O \end{matrix} = 2H_2O + O_2$$

Since the formation of formic acid is not very probable, we might substitute the following equation which would express an eventually direct formation of formic aldehyde, which by condensation may yield sugar.

$$O{=}C{<}^{OH}_{OH} + \begin{matrix} HOH \\ HOH \end{matrix} \text{ becomes } O{=}C{<}^{H}_{H} + \begin{matrix} H_2O_2 \\ H_2O_2 \end{matrix}$$

$$2H_2O_2 = 2H_2O + O_2.$$

Pfeffer[2] gives the following declaration against the above hypothesis: "Erlenmeyer supposed that formic acid and hydrogen peroxid are formed during the assimilation of carbon dioxid—a theory which the absence of hydrogen peroxid from assimilating plants conclusively negatives." The undeniable fact that all reagents fail to show the

[1] Berichte der Deutschen Chemischen Gesellschaft, 1877, p. 634.

[2] Physiology of Plants, Vol. I, p. 356 (1900.)

presence of hydrogen peroxid in the cells can not, however, be accepted by a critical mind as a proof that it is not formed at all, since it would have only an ephemeral existence. By its rapid decomposition it would give rise to the oxygen developed by the chlorophyll bodies—a view which would find some support if it could be shown that the chlorophyll bodies are very rich in catalase.

While Pfeffer's objection can not be considered a serious one, some better-founded chemical objections might be raised. It is a fact that chemistry does not show a single instance where two hydroxyl groups can unite to form hydrogen peroxid. Such a process would be improbable, although not impossible.[1]

[1] Brühl (Ber. d. Deutschen Chem. Ges., vol. 33, p. 1710) maintains that hydrogen peroxid can not be a simple "bihydroxyl" HO—OH, but that the formula HO ≡ OH would correspond better with its behavior, since it is free of electric absorption and shows a very high dielectric constant.

S. 46.

U. S. DEPARTMENT OF AGRICULTURE.

Report No. 70.

# EXHAUSTION AND ABANDONMENT OF SOILS.

TESTIMONY

OF

MILTON WHITNEY,

*Chief of Division of Soils,*

BEFORE

THE INDUSTRIAL COMMISSION.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1901.

# LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF PUBLICATIONS,
*Washington, D. C., July 25, 1901.*

SIR: By invitation of the United States Industrial Commission, Prof. Milton Whitney, chief of the Division of Soils, appeared before that body on March 12, 1901, as a witness in regard to the causes of the exhaustion and abandonment of soils. Professor Whitney, in his testimony, gives in considerable detail the causes leading to the abandonment of large areas of land in the New England and Southern States particularly, and in the far West incidentally, together with many valuable suggestions for the reclamation of these deteriorated soils. The subject is of considerable general interest, and it is believed that the republication of the testimony, which also embraces statements relating to other matters allied to agriculture, will serve a useful purpose and enable the Department to meet demands for the information therein contained, upon which there is now no available publication. I have the honor, therefore, to recommend the publication of the testimony as Report No. 70 of the Department.

Very respectfully,

GEO. WM. HILL,
*Editor.*

Hon. JAMES WILSON,
*Secretary of Agriculture.*

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# EXHAUSTION AND ABANDONMENT OF SOILS.

## INTRODUCTION.

At the meeting of the United States Industrial Commission on March 12, 1901, at Washington, D. C., Mr. Phillips presiding, Prof. Milton Whitney, chief of the Division of Soils, United States Department of Agriculture, was introduced as a witness, and, being first duly sworn, testified as follows:

Q. (By Mr. CLARKE.) Will you please give your name and post-office address, and also state your official position?—A. Milton Whitney, Takoma Park, D. C. I am chief of the Division of Soils, Department of Agriculture.

Q. How long have you been in your present position?—A. About six years.

Q. Had you, before coming to that position, been engaged in studies like those you now pursue?—A. Yes; I have been engaged in the study of soils for the past eighteen years.

Q. In how many States?—A. I began in Connecticut at the Connecticut Experiment Station, and was then in North Carolina as superintendent at the experiment farm; then as professor of agriculture in the University of South Carolina; then as professor of soil physics in the Agricultural College of Maryland.

Q. Of what State are you a native?—A. Maryland.

Q. The commission will be pleased to have you proceed in your own way to describe the character of your work in the Department of Agriculture, and especially as to how you gather the soils and how you make your experiments.—A. My understanding was that the main question which would come up would be the very important subject of the exhaustion of soils and abandonment of lands, particularly with reference to the New England States and the Southern States, and incidentally the abandonment of certain lands in the West; to see if cause or causes could be assigned, and if there were any suggestions for remedial measures.

Q. Proceed, if you please, in your own way, then, to develop that particular subject.—A. It is doubtless well known to the commission that there are large areas of land in the New England States that

have been abandoned; that there are large areas in the Southern States that have also been practically abandoned and given over to waste; furthermore, that there are large areas in the far West which have once been settled and which have since been abandoned or are now held in very low esteem.

## CAUSES OF THE ABANDONMENT OF SOILS.

### EXHAUSTION.

The cause of the deterioration of the lands in the South has been commonly ascribed to the exhaustion of the soil, and this is the first consideration that I wish to take up. The exhaustion of the soil is due, in my opinion, to changes in the chemical and physical properties of the soil rather than to any actual extraction of plant food.

A soil, to be productive, must render annually, as the crop needs it, a sufficient amount of food material in a form available to the plants. As a matter of fact soil is a difficultly soluble substance, composed mostly of silicates and aluminates, or difficultly soluble compounds of silica, alumina, potash, soda, and lime in various forms. Through atmospheric agencies, largely, these compounds are rendered more or less soluble and more or less readily available to plants.

A fertile soil is one in which the weathering effects come in at such times and to such an extent as to render available to plants a sufficient amount of this plant food. If that weathering does not take place and the food material is not brought into a condition in which it is available to the plants, the land is as poor as though it actually contained no plant food.

I have never in my experience seen a case in which one could say with any degree of certainty or even of probability that exhaustion was due to the actual removal of plant food. It is perfectly safe to say that the condition of the so-called worn-out soils in the South is due, not to an actual extraction of plant food, but to the chemical condition in which it now is, in which it is unavailable to plants, and that the restoration of the fertility of that land must be, not necessarily in the addition of plant food to the soil, but in bringing about such changes in the physical conditions or in the chemical combinations as will encourage that natural weathering of the soil which brings the plant food into a condition in which the plant can get its support.

To emphasize this statement, which may appear at variance with the general ideas concerning the exhaustion of soils, I would call the commission's attention to the many cases in which soils have been cultivated for hundreds and thousands of years. So far as we know, within historic times they have been constantly cultivated, and cultivated in the same crops. We have the case of the soils of India, which tradi-

tions say have been cultivated for two thousand years, under primitive methods, without artificial fertilizing, and which still give fair returns of the common crops of the country. We have the case also in Egypt of lands which have been cultivated since history began and where the soils are as fertile as ever. We have all through the southern countries of Europe, and still later in the countries in the north of Europe, in Holland, in Denmark, in France, in England, records of the continuous and profitable cultivation of soils for five hundred years—away back to the time when history first opens up our knowledge of these countries.

There is one phase, however, that it would be well to dilate upon here, namely, that with our increase in density of population and with the competition that has been going on, we are no longer satisfied with the yields that are naturally obtained from many of our soils, and we have resorted to the practice of fertilization in order to force plants to produce far beyond what the natural fertility of the soil will give.

There are historic experiments that have been going on in England for the past fifty years in which a crop of wheat has been grown continuously without fertilization, and the yield has steadily fallen from what it was at first (I forget the figure) until it now produces about 12 or 13 bushels per acre. For the past twenty years there has been little or no difference in the yield, except slight fluctuations due to seasonal conditions, and it is believed that the yield that is now obtained measures approximately the power of the soil to produce a crop under perfectly natural conditions. It will produce annually, so far as we know, for hundreds of years 12 or 13 bushels per acre.

Q. Are you able to state whether the kernel is as full and well developed now as it was in the earlier conditions?—A. So far as we know, the grain is of the same value, pound for pound, but not being satisfied with a yield of 12 or 13 bushels per acre they have, by the use of fertilizers and manures, increased the yield on adjacent plots to an average of about 30 bushels per acre. In this forcing of the crop they have found that they could economically increase the production from that soil. The first we would call the natural fertility and the second the acquired fertility. One is perfectly justified in recognizing these two characteristics in the production of the soil: What it will naturally produce through a course of years under the natural weathering of the material, and what it can be made to produce by the artificial application of more food material than the plant can secure through the natural weathering. If the natural yield from a soil becomes so low as to make it unprofitable, it may often be necessary to fertilize in order to make the soil productive.

### DEVELOPMENT OF NEW AREAS AND NEW INDUSTRIES.

The second cause of the abandonment of soils arises from the development of new areas and new industries. There is no question that the opening up of the western country, the great corn and wheat producing States of the central West, the wheat lands of California and of the Red River Valley of Minnesota and Dakota, has had a great influence upon the agriculture of New England and all our Eastern States and has done much toward bringing about the conditions that are now prevalent. This will be taken up more in detail later.

In the line of the introduction of new industries I would cite the case of tobacco: Before the war tobacco was grown very generally in the State of Maryland, and since the war it has been grown extensively in the southern counties only; but with the introduction of the White Burley tobacco in Ohio and Kentucky—which produces a large yield and which can be produced with profit at a comparatively low price—the tobacco industry in Maryland has been largely given up, and the effect of this change on the farmers of Maryland has been very disastrous, because tobacco has been one of the staple products of that portion of the State.

Another instance that I should cite is the development of the truck industry. Fifteen or twenty years ago the truck industry was in a very flourishing condition in Maryland. Truck was grown very extensively on certain classes of soil which were not adapted to other lines, and there were certain localities in which the people were extremely prosperous. But with the development of transportation facilities, with the opening up of truck areas in the South, in South Carolina and in Florida, and with the production of those early vegetables which could be rushed up to the Northern markets in the winter and early spring, the industry has languished in certain localities to such an extent that it has been given up. That is the cause of the abandonment of farms in certain sections of the Atlantic coast States.

Q. (By Mr. KENNEDY.) Are you going to discuss the question of irrigation—whether it will have a still further effect to cause abandonment of poorer lands?—A. I will speak later of the West, but I will bring this in at this time, though I was going to speak of that particularly in connection with the New England States.

Q. You had better take your own order probably.—A. I will be glad to answer any particular question as we go along, though.

### ATTEMPTS TO GROW CROPS UNSUITED TO PARTICULAR SOILS.

Another very important contributing cause to the abandonment of lands has been in the unfortunate ventures that have been made in bringing a people from a distance to settle a region with which they are unfamiliar, and to grow crops with which they are themselves

acquainted in the localities from which they come, but which they have no appreciation of as adapted to the localities into which they are going. The Department of Agriculture is constantly in receipt of requests for information as to where certain settlements of people could be made—people who are to be brought in to grow alfalfa, to grow stock, to grow tobacco, or other crops. And very frequently the utmost ignorance is shown as to the localities which are to be selected and as to the conditions into which they are going.

There have been many instances of failure from these causes alone in the States of Maryland, Virginia, Pennsylvania, and in fact throughout the country.

One instance I would speak of particularly that has come to my personal attention is a settlement in one of the Western States. A large area of land was taken up and put under irrigation. Agents were sent from this country abroad to attract immigration. People were brought from Switzerland, from France, from Germany, and an extensive plan of development was outlined. They were to introduce the European grapes; they were to introduce and develop the sugar-beet industry; they were to take up all kinds of fruits that had been successful in their own districts; they were to grow truck crops, and they were to develop large grain and cattle interests. But the plans completely failed, as their soils and their water and their climate were not fit for the industries that they started. After a most disastrous and expensive experience they have lost their crops; they have found that fruit will not grow; that the grape is not suited to the conditions there. They have lost their money, and they have come to a realization of the fact that the country and the conditions are adapted simply to grazing; that if they grow alfalfa and stock they can do well, but they can not do well with their fruits and with their sugar beets, because the conditions there are not adapted to those crops.

Q. Would you state what the location is?—A. It is an area in New Mexico that I am referring to. It is an experience in the Pecos Valley. The principal reason for the failure in that case is due to the condition of the irrigation water. It is very alkaline, which these people did not know when they went into that region. Their failure was also due to their unfamiliarity with the conditions in that locality, and their attempt to grow something that they had grown in Switzerland or in Holland under conditions which were entirely different. In this arid region, where they have to use water to produce any crop, the only available water has been found to be unfit at times for irrigation. This is a cause of the abandonment of large areas of land, not only in New Mexico but in other portions of the West.

UNFAVORABLE CLIMATIC CONDITIONS.

Another contributing cause of the abandonment of lands has been in the selection of localities in which there are unfavorable climatic conditions. The commission is doubtless aware of the conditions in Kansas and in portions of Nebraska and of Colorado—how, during the boom times of fifteen or twenty years ago the country was settled, towns were established, and farms were obtained with the idea that fortunes could be made on the agricultural products of the country. Cotton mills were put up out in the semiarid regions, and are still standing as monuments to the unfortunate schemes and ventures that were devised.

Q. (By Mr. CLARKE.) Could you state what the cause of failure was in that section?—A. Yes; I will come to that.

Q. (By Mr. KENNEDY.) You do not mean cotton mills in Kansas and Nebraska?—A. Yes; there are abandoned cotton mills in Kansas and Nebraska.

Mr. TOMPKINS. There is one at Kearney, I think.

The WITNESS. In explanation of the conditions just stated, it may be observed that the semiarid region of the country extends generally from the one hundredth meridian to the foot of the Rocky Mountains, and embraces in my definition such areas as have from 15 to 20 inches of rainfall per year, but so distributed that only occasionally are the seasonal conditions favorable for crops. When they have a favorable season, or two in succession, as they frequently do, they get fine yields and make good returns, but in three years out of five, when they have their disastrous droughts and get nothing, the profits of the two successful years are entirely used up.

With less than 15 inches of annual rainfall lands are seldom or never successfully cultivated, so far as I know, except in certain areas in Washington and California. With 20 inches of rainfall (that is half what we have in the East), provided it is fairly well distributed, good crops can be grown in the semiarid regions; but it is the uncertainty of the seasons which renders farming unprofitable. It is the uncertain and unequal distribution of the rainfall that has caused so many disasters and has been the reason of the abandonment of so many farms.

It is perhaps one of the most serious problems, that of the semiarid regions, that we have in the agriculture of this country at the present time. In the far West such conditions can be overcome where irrigation is practicable, but so far as known there is no bright future for irrigation in much of the semiarid regions of the country. In Kansas there were in 1889 only 20,000 acres of land under irrigation. In North Dakota, South Dakota, Nebraska, Kansas, and Texas there were only 67,000 acres of land under irrigation in that year, and the possibilities of getting water are small in comparison with the vast areas that would need to be watered to be permanently and safely productive.

Another cause that has contributed to the abandonment of lands in the semiarid regions has been the deterioration of the ranges and the consequent injury to the cattle industry. A division of the Department of Agriculture is actually giving its attention to the investigation of the range problem and the possibilities of conserving and maintaining the ranges, and this being the case, it would hardly be proper for me to discuss this subject at greater length here. It seems to me, however, that it will be necessary and wise to adopt some legislation to protect the ranges in the West, and to prevent the terrible destruction of property which is going on through close grazing, against which there is no restriction in many of the areas of the West. It seems to me that this is a problem for legislation, as it is at present too difficult for the agriculturist to deal with and much of it occurs upon the public domain. Where range lands are rented for 5 cents an acre little expense can be put upon them for improvement. There is little chance at present to make any improvement in the agricultural conditions where land is so cheaply rented, so cheaply purchased, and so carelessly used.

Another example of unfavorable climatic conditions may be cited in the Connecticut Valley, right here in our Eastern States. With a rainfall of about 40 or 50 inches, we have soils that have been abandoned from the same unfavorable climatic conditions—a deficiency of rainfall—as prevail in the semiarid regions of the West. I refer particularly to the Windsor sand, which occasionally produces a very fine crop of tobacco, but the soil is so coarse and leachy that it is only about two years out of five that the conditions are favorable. In the favorable years they get good yields and the farmers are very prosperous and contented; in the other three years out of five, as in the West, the soils dry out and are subject to such disastrous droughts that they are entirely unproductive. The expectation of getting a crop even two years out of five has induced many farmers to hold on until finally there have been successive seasons of failure, and they have had to give up. Under conditions of well-distributed rainfall the soil produces, as does the semiarid land in the West, but it is a desert for three years out of five.

Q. (By Mr. PHILLIPS.) About how extensive is that area?—A. The area in the Connecticut Valley is not large, but along the Atlantic seaboard, in the aggregate, it covers a large area. These coarse, sandy soils are found from the New England States all the way along the Atlantic seaboard and around the Gulf, and many farms have been abandoned on these areas simply because of the unfavorable climatic conditions for these particular soils when other soils surrounding them are favored by the same conditions.

I would cite also another instance to show the effect of unfavorable climatic conditions on the abandonment of soils, namely, the orange

industry in Florida, where they have grown oranges with great success for years and where the industry has flourished in the most promising way until a season of frost and freezes that has thrown back the industry for years and has ruined a large number of people. This is a contributing cause to the abandonment of lands, which can not be overlooked in the consideration of the subject.

### SCARCITY OF WATER IN DESERT COUNTRY.

Another cause for the abandonment of lands is found in the scarcity of water in our desert countries. The public lands of the arid States amount to 560,000,000 acres. Only 3,600,000 acres were irrigated in those States in 1889 and only 74,000,000 acres are capable of being irrigated, according to the most careful estimates of the Geological Survey. We have, then, the difference between the possibilities of 74,000,000 acres and the actual extent of 560,000,000 acres, which are used to some extent for grazing lands, and upon which living is, at the most, extremely precarious. Many areas have been abandoned which have once been settled, simply because of the extreme scarcity of water and the impossibility of producing agricultural crops or promoting agricultural interests.

### ALKALI AND SEEPAGE WATER.

Another important cause of the abandonment of lands is found in the alkali and seepage waters of the West.

I would call the attention of the commission to some work the Department is doing in Salt Lake County, Utah. This was one of the earliest settlements where irrigation was tried in our modern civilization of this country. When the Mormons first settled the place they naturally took up the richest bottom soils along the Jordan River. The soils were naturally filled with salts, but with the drainage that was started and from the character of the soils themselves the salts were quickly removed and the lands were in splendid condition for agricultural use.

In the further settlement of the country, in the increase in the density of population, as the settlers moved up on the high lands and the water applied at higher elevations, the seepage of water from the canals accumulated in the low places and brought with it the salts, which accumulated to such an extent in the low places that the first lands, the most fertile lands of the valley, were rendered entirely unfit for cultivation. They were wet and swampy, and they were filled with alkali, and the history of this once prosperous community has been that the people are moving up onto the bench land, and are abandoning soils which were once the most productive in the State.

In the area which we surveyed in Salt Lake County, between the Jordan River and the Great Salt Lake, about 50 square miles of land

has been successfully cultivated under irrigation. Of this, 10 square miles, or nearly one-fifth of the whole area, has been ruined and has been abandoned as worthless and useless, and the injury is progressing. Lands are constantly being turned out which have been swamped with seepage waters and which have been filled with alkali.

This is one of the most interesting and most important problems of the West, and one which I should like particularly to bring to the attention of the commission, because it seems to me that something will have to be done, through either State or national legislation, to stop the injury that is going on.

Q. Have you any theory as to how to stop it?—A. I will go on to state that. The conditions may be briefly stated thus: The canal company, whether organized by the farmers or organized with independent capital, constructs a canal and maintains a certain level or uniform grade, going through all kinds of soils which it may be necessary to go through in the construction of its canal. It happens in the Salt Lake Valley, as in many other localities that we have studied, that this canal goes for several miles through a gravelly soil, in which there is a great deal of seepage and loss of water. The water is plentiful and of good quality, so the canal companies are not concerned with the loss. They have a bounteous supply from the Utah lake, and they are getting good water, free from alkali. But the water in seeping out through this gravelly area is slowly filtering through the soil, carrying with it a relatively large quantity of salts, which are in all arid soils, and are concentrating the salts in the lower lands and are filling up the lowlands with water, until, as a matter of fact, there is a string of lakes out in what was once an arid, desert country—artificial lakes on what were later fertile and well-cultivated soils, and which are now abandoned lands and tule swamps.

It seems to me that the farmers situated on those lower levels should have recourse, through civil suits, to damages, and the canal companies maintaining canals under such conditions should either be compelled to protect their canals from seepage or to pay damages to the farmers whose lands are ruined.

These conditions are exceedingly pernicious. If you have a soil under the most careful methods of cultivation, farmed with the most expensive varieties of fruit or other farm products, taking the utmost care, giving the greatest attention to all methods of growth so far as your experience and your skill or the knowledge of your experts will indicate, it is certainly most exasperating to have the land swamped and filled with alkali from a leaking ditch situated perhaps 3 or 4 miles away, and over which you have no possible control. It is an exceedingly pernicious thing, for which some recourse should be had in damages. But, so far as I know, there is nothing to stop it. The lands are going to waste, and one-fifth of the irrigated lands of that district

alone have been abandoned from this cause—a cause which could have been provided against. These lands could have been protected and these farms could have been saved.

Another instance that I would cite in connection with this district is the extensive area that is situated just west of Salt Lake City and extending over to the Great Salt Lake. There is an area of about 90,000 acres, and it comes close up to the Jordan River and extends across to the Salt Lake. The land is filled with alkali, but it is not always apparent on the surface. Frequently the surface looks like a fertile, easily cultivated loam, and many attempts have been made to settle the country. Many farms have been laid out, canals have been constructed, water has been let onto the places, town sites have been located, railroads have been projected and built, and with the first application of water good crops have been produced; with the second, a failure. With the third application the land has become so salty that it is abandoned as a waste and desert land. Thousands of dollars have been invested in the settlement of that tract, and thousands and thousands of dollars have been lost in the fruitless effort to build up an agricultural industry in that area, and this is the cause of the abandonment of these soils—because of the occurrence of alkali not always seen from the surface, but always lying in the lower depths of the soil ready to come up at the first application of water. It will be interesting to state that the result of our soil survey convinced us that it was perfectly feasible to reclaim these lands. There is sufficient fall to put in a drainage system. The soils are naturally easily worked. The expense would be no greater than the drainage of lands in Ohio and Illinois, and the profit that would be realized from the reclamation of the 60,000 acres of land situated on that tract would amount, in our opinion, to about $3,000,000 in property valuation. Now, a very singular thing has arisen in regard to that section, that while the people seem to realize that drainage may reclaim the lands, yet they seem to be averse to having the drainage work done, and the people who have desired to follow our advice have been unable, in certain cases at any rate, to do so from the objection of their neighbors. There are no drainage laws, as there are in Illinois and others of our our Middle States, and the enterprise is stopped right here by the inability to have any recourse to State laws, and by the unwillingness of the people to give access to the drainage canals through their places. This is a matter that I shall refer to later in my remarks upon drainage.

Q. (By Mr. KENNEDY.) Where does the water for irrigation come from—is it mountain drainage?—A. The water is from the mountain streams, fed in this case into Utah Lake, which is a fresh-water lake, and is taken out of the Jordan River.

Q. (By Mr. FARQUHAR.) What is the elevation between the Great Salt Lake and the river?—A. Twelve feet between the level of the

river at Salt Lake City and the lake, but there is a ridge going through the district that gives about 2 feet per mile of fall on either side, and in addition to that there are extensive washes that extend up through the land that would form natural outlets to the drainage system. They run up for 8 or 10 miles into the country.

Q. (By Mr. KENNEDY.) Is the recession of the waters of the Great Salt Lake having any effect on the soils and climate of Utah?—A. It is having a great effect upon the soils. The level of the Great Salt Lake has fallen 14 feet since 1865, and in our survey this year of the area around Ogden we mapped in 60,000 acres—about 10 square miles area—where the lake had receded, and we established the shore line of the lake in some places 9 miles beyond where the former survey had placed it.

Q. (By Mr. PHILLIPS.) What is the cause of the fall of that lake, in your judgment?—A. There is an annual fluctuation that has never been explained, and there are periodical fluctuations that have never been explained. The level has been known to vary from period to period for reasons that are not at present known, but in addition to that the withdrawal of a large amount of water that is being used now for the irrigation of the surrounding lands, which does not go into the lake as formerly, is certainly a very large contributing cause to the lowering of the present surface.

Q. You spoke in regard to canals through the sandy soil portion, saying there ought to be something done to remedy the evil. Have you any theory? Could the water be carried through pipes and thus prevent seeping through the soil?—A. I would state that in California, where water is more valuable, where the companies themselves are financially interested in how much water they sell, it is very common to protect canals from loss by seepage by running through wooden troughs or through wooden pipes, or as is frequently done where the water is carried through sandy areas, by cementing the sides and the bottoms of ditches. We have photographs (I wish I had brought them with me) of large-sized canals and laterals, constructed in California, with the sides and bottoms cemented.

Q. That would be entirely practicable—to prevent seepage and thus prevent the destruction of lands below?—A. It is entirely practicable. In many cases simply the puddling of the canal would be sufficient, but where seepage causes injury by alkaline deposits, in my opinion, it should be stopped, and the companies should be required to protect their canals from undue loss.

### FLOODING AND INUNDATION BY STORMS AND TIDES.

Another cause of the abandonment of land is flooding and occasional inundations by storms and tides. The commission, of course, is well aware of the enormous losses from floods in the Mississippi Valley, and

from the recent floods in Texas. This is a matter of such common knowledge that it hardly seems necessary for me to dwell upon it as one of the important causes of the abandonment of soils, where the conditions are so unsafe that settlers can no longer risk their lives or their crops. But I would call your attention also to the vast extent of the tide marshes and inland swamps of the United States. This question of the tide marshes has recently been brought to the attention of the Department of Agriculture from its economic importance in the New England States. It is estimated there are 168,000 acres of tide marshes along the Atlantic and the Gulf coast; and on the Pacific coast it is estimated that there are several million acres of tide marshes. These lands, if protected from the tide and drained, would be of value in agriculture. Some of the inland swamps of Illinois which were selling originally at $1 to $5 an acre have a value now from $60 to $100 an acre. It is estimated that one-fifth of the area of Michigan is swamp land, which, if drained and reclaimed, would be of great value for celery and corn and potato crops. The tide marshes have also an indirect effect upon the values of adjacent lands, because of the prevalence of disease and the prevalence of mosquitoes. I would not say tide marshes only, but all marshes. The commission, of course, is aware of the commonly accepted views now that malaria is conveyed by mosquitoes, and the Department of Agriculture has been applied to recently from many sources to suggest means of reclaiming the tide marshes and the inland swamps of the United States, partly for their agricultural value and partly for the increase of the healthfulness of the surrounding land. There are many cases where areas and industries have been abandoned from the unhealthfulness of the neighboring marsh lands. I do not know that there is any cause that has contributed so much to the discomfort of many of the Atlantic coast States immediately upon the water, which would otherwise be a delightful location and a fine farming land, as the prevalence of malaria and similar diseases. That these causes have prevented to a large extent the settlement of some of our Southern States and have been the cause of abandonment of some others of our lands is unquestionably true. The prevalence of malaria and these malignant fevers near swamp lands of the South, the unhealthfulness which almost prevents the residence of white persons, is a matter that calls for very great and grave consideration, and it is one that the States, at least, it seems to me, might well consider.

An instance that I would cite as to the effect of inundation and floods as a cause of the abandonment of soils is in the rice lands of South Carolina. These lands before the war were protected by substantial levees that were built through cooperation between the individual and the State and maintained as a protection against the flooding of the fertile swamp lands by floods or by tides. During the period of the

civil war these levees were destroyed, the lands were for a time abandoned, and since that time it has been impossible to get labor to work in the canals, and it has been expensive to construct the levees, and large areas of this once fertile and extremely productive soil have been abandoned from this cause.

Q. (By Mr. CLARKE.) Why has it been impossible to get labor to reclaim this land—on account of unhealthfulness of the climate?—A. On account of unhealthfulness and the unwillingness of labor to work under conditions they have to in the swamp lands. In a way it would seem that machinery could be introduced, dredges; but so far as I know this has not been done on any extensive scale.

Q. Have you given attention to the development of rice growing in southwestern Louisiana?—A. Yes. The conditions there are that these lands, which were semiswamps, have been drained where necessary, and they are not subject to overflow, as the rice lands of South Carolina are. The Louisiana lands are higher, but still they are swamp lands, and the irrigation that is given to these lands is done by pumping or by artesian flow, usually by pumping, whereas the irrigation of the rice lands of South Carolina is from the rivers, and is without any pumping or artificial means, either for irrigation or for drainage.

Q. It is in evidence before the commission that the Louisiana rice region is very healthful.—A. That region is much more healthful than the South Carolina rice lands.

### LABOR AND EXPENSE OF MAINTAINING PROPER PHYSICAL CONDITION.

Another cause of the abandonment of lands, at least a contributing cause, is the expense of maintaining the proper physical conditions. The trouble and expense of clearing the stones off the New England fields have been so great and so laborious that they have had something, at least, to do with the abandonment of lands in that locality. The simple expense and labor involved in getting the fields into condition and maintaining them in condition to cultivate in competition with the large areas of the fertile Western plains have been so great that they have unquestionably been a contributing cause to the abandonment of the soils. And the labor and expense and risk in maintaining the proper conditions of the rice lands of South Carolina, which I will refer to again, have been so great that there also these factors have operated against the continuance of the culture of the lands, and have been an insurmountable obstacle to the reclamation of what were once fertile and well-cultivated soils.

### TRANSPORTATION CONDITIONS.

I would mention also the effect of transportation facilities. While cheap transportation has opened up new and important markets, it has also been the cause of the development of extensive areas of new and

exceedingly fertile country. The effect of this cause alone in the New England States and in the South has been very great, and will be referred to in a later place.

Another cause has been unquestionably the discrimination in rates and the high freight charges which have prevailed in certain localities. It is not my purpose to go fully into this question, as the commission has had in evidence before questions touching this important subject, but in my experience the commercial value of farm lands is often controlled to a considerable extent by the rates of freight which are locally applicable to these areas. It may be that the lands are situated at such a distance that cheap transportation can not be offered; it may be that there are conditions of expense in the marketing of the products, but certain it is that the possibilities of building up industries, agricultural industries, on certain soils and under certain climatic conditions which in themselves would be favorable is prevented by the impracticability of marketing the products with any profit under the prevailing conditions.

Q. (By Mr. PHILLIPS.) What section of the country is that most applicable to?—A. I would cite, in the case of Florida, the marketing of the bulky and tender products from the truck fields. These products have to be marketed under peculiar conditions. They have to be rushed to the Northern markets on the fast freight or passenger schedule. They have to be provided with proper refrigerating and ventilation cars, and they must be placed upon the market in the shortest possible time in order to be in fresh eatable condition, and to reach the market at the earliest possible date. Now, it is the common experience in Florida that the possibilities of marketing the crop with any profit to the farmer is a pretty close thing to figure on, and that it requires very nice and very close calculation in many cases to determine whether it is possible to send a crop to the Northern markets with any profit. I do not mean to say that there is discrimination, but I do want to show the commission that the possibilities of marketing the crop, the possibilities of transportation, have necessarily something and in many cases much to do with the possibilities of the development of any particular agricultural district, and that that is one of the important factors in the abandonment of many enterprises that have been started—in the abandonment of lands.

Another cause of this same kind which could be cited is in the marketing of the truck crops of southern Maryland. The development of the truck industry there a few years ago was very great, and the product had to be sent by river steamers to the railroad centers, or to the Northern market, and they were picked up by these steamers on their regular runs. The amount of product was large, the distance from the market was great, and the time that was consumed in getting the crop loaded and delivered in the Baltimore or Washington or Phila-

delphia markets became so great, and the transportation service was so irregular, that the industry on large areas has been given up for that one cause, namely, the inability to market the products in the proper way and in the quick time that is made necessary by our present transportation facilities.

Q. (By Mr. CLARKE.) You do not think that the difficulty of getting suitable farm labor for this truck farming was a potent factor in causing the abandonment of it?—A. Decidedly. I shall speak of the condition of labor in the South later on. This is an important contributing cause.

SOCIAL CONDITIONS.

To come now to one of the most important problems—the social conditions and growth in manufactures, and the increase in wages.

*New England.*—In treating this I shall take up specific cases, first, of the cause of the deterioration and abandonment of lands in New England, about which so much has lately been said. So far as I am aware, there is no evidence to show that the New England soils have any less plant food than they had when first cultivated. That is to say, that so far as the chemical analysis would show, they have all of the essential ingredients for crop production. I do not mean to say, however, that the soils are in as high a state of cultivation as they were, because I do not think that is universally the case; but the exhaustion of soils as it is usually considered has not contributed to any great extent to the present condition of the agricultural lands of New England in the two hundred years in which they have been cultivated. It would be impossible, with the record we have of Eastern countries, to conceive that in two hundred years these soils could be so impoverished by the actual withdrawal of plant food by the crops that have been marketed as to make them markedly deficient in plant food. We must remember that the country throughout the New England States has generally a rough, hilly, and frequently a stony soil, with rocks and bowlders and gravel, left from the Glacial period. The expense of clearing and cultivating these rough and rocky soils is considerable. With the development of the fertile lands in the West, with the ease of cultivation and the methods that can be employed, the cost of production has been reduced. The New England farmer can no longer afford to grow the staple farm products. When wheat was bringing $1.25 and $1.50 a bushel, as it was a few years ago, and when hay was correspondingly valuable and cattle a correspondingly important industry, the products from the New England farms were profitable. There is no question that the New England farmers made a comfortable living; but with wheat as low as it is at present, with cattle as cheaply raised as they are in the West, and with hay and

grain as abundant, they have been unable to compete. The contributing cause of this condition has been the small areas which they could devote to any particular crop, and the labor and expense of cultivating and caring for their land. The development of transportation facilities, the lowering of freight rates in the rail and lake and canal transportation, has made it possible to bring products from the West at such a low price that it has been impossible on the rough and rocky New England soils to compete.

Another very important contributing cause has been in the increase in the number and size of factories. It is unquestionable that the social conditions of New England have changed in the past few years—that the growth of the factory system, that the increase in wages, that the lesser cost of the products of the mills, the increase in the number and variety of articles that are considered necessary for comfort and health, the general increase in the cost of living, the general feeling of discontent, and the unwillingness to remain in the quiet and laborious life of the farm have all had their influence.

It seems to me that of all the causes that have contributed to the abandonment of the lands in New England there is no other factor that has been more potent, more important than this one, of the success of individuals in the commercial and industrial lines, and the apparent ease and comfort and luxury of their lives as compared with the laborious and simple life of even the successful farmer.

Q. (By Mr. KENNEDY.) I read in the public press a short time since that the abandoned farms of New England were being taken up again at a very low price; that those who had abandoned them and gone to the West in many cases were returning and trying to get the old homesteads, and that if they could not do that they were buying abandoned farms in the neighborhood, and in one of the New England States, in Massachusetts or Connecticut, there was not now a single abandoned farm.—A. I think there is a reaction going on, but I should think that statement rather overdrawn. Unquestionably, however, I think there will be a reaction, and that the lands will be taken up.

Q. (By Mr. PHILLIPS.) Have not a considerable portion of those lands been taken up by French Canadians in recent years?—A. Yes; they have. One other point I wish to convey to the commission is that the lands in themselves are not worn out; they are in no worse condition. It is other conditions, and not the actual exhaustion of plant food, by which they are affected.

Q. (By Mr. CLARKE.) Is it not a fact that the products of agriculture in the manufacturing sections of New England are worth more to-day than they ever were before?—A. Do you mean of wheat and grain and fruit?

Q. I mean all crops grown by farmers, including of course, truck farming.—A. Well, I should say not, so far as the general farming

goes. Special industries are exceedingly important in the New England States, and I had aimed to speak of that fact in my suggestions for the amelioration of the conditions.

Q. Instead of manufacturing having the effect of depopulating the farms and of rendering agriculture unpopular, is it not true that manufacturing affords so good a market to the farmer near his farm that by changing his agriculture somewhat he finds it more profitable than ever before?—A. Have you not really given the key to the whole situation, namely, that they have not changed their method; they have persisted—farmers are a conservative class—in attempting to compete with the West, when they should have specialized and have met the changed conditions that have confronted them?

Q. My observation, as a New England man, reared upon a Vermont farm and an annual visitor to that State, and somewhat familiar with conditions in Massachusetts, where more manufacturing is carried on, is the reverse of that, and it is that they do conform to existing conditions and are making more money than they ever made before. Now, if I am wrong about that I hope that you or somebody else in the Department of Agriculture can enlighten the country on that subject. A few years ago a Professor Perry, of Williams College, made the statement that one-third of the farm lands from the summit of the Green Mountains in Vermont eastward to the Connecticut River had been abandoned. I contradicted it at the time from personal knowledge. That is one of the most favorable regions in this country. There is scarcely an abandoned farm to be found there, and agriculture near that region, while it has undergone some changes, is more profitable than ever before, and I would like to know why it is. As you say, the soils continue to be fertile and productive, and the markets have improved, and transportation facilities have improved; why is it, then, that the people will persist in claiming that there is a large abandonment of profitable agriculture in that region of the country? I undertake to say that it is not true, but that the exact reverse is true.

Q. (By Mr. PHILLIPS.) Is it or is it not the fact that the price of lands both in New England and the Central States, Pennsylvania, New York, and Ohio, are not nearly as valuable and would not bring as much per acre to-day as they would twenty-five or thirty years ago, or even before the war?—A. Generally, the land values have fallen, but in specific cases they have risen or have maintained their level. And in many cases in the New England States it is unquestionable that very important industries have been created there, notably the tobacco interests of the Connecticut Valley, which we have lately had under consideration, the area of which we have recently mapped; also the truck interests along the Sound, around Providence, around Boston, are very important, and the fruit interests of the Lower Connecti-

cut Valley, particularly the peaches, have all been exceedingly profitable, and I hope I did not convey the impression that I believed myself that there was any such general abandonment of lands as has been frequently stated in the press, because I think myself that there are many industries in the New England States now that are very important. It is certainly our most important tobacco section—the most important for wrapper tobacco—the finest we get in this country.

Q. Is it not a fact that throughout New England when a farm has been abandoned as a home it has been annexed to some neighboring farm and still carried on as a farm? Is not that almost universally the case?—A. I would not say universal, but it is generally the case; yes. There can be no question, however, that, particularly in the last ten years, twelve years, there has been a period in New England in which agriculture has been at a low stage, and that there have been many abandoned tracts, and many people who have moved away. I have tried to show that these conditions are due to causes other than the poverty of the soil, which I do not believe in at all, and that there is no reason why they should not build up the industry of that country and make it as profitable as, and far more profitable by adjusting it to these new conditions, than it ever was.

Q. Now, I would like your estimate of the proportion, the relative importance of the causes which you have named which have contributed to this soil abandonment. Is it not, in your opinion, mainly due to the competition of the more fertile lands of the West—that is, the more easily tilled lands?—A. I should give that as the first cause, and I should give as the second cause, the increase in the factories, and the demoralizing effect of the factory life and of the factory wages upon the farm people. There is a demoralization; it is more a panic than anything else; they have not the mature sense of perspective, the vision of what can be accomplished if they take new opportunities which have come to them. It is common through our Eastern States. It is a restless feeling that their old conditions have been changed, and a lack of that business planning and management that will enable them to fit their agriculture to new conditions.

Q. Do you think that the young men leave the farms in New England for the factories?—A. I think so.

Q. Have you any information on that subject?—A. I speak from my experience in New England. I lived in New England for many summers when I was a youth, and I have frequently visited there, as it is the home of my father. I spent two years at the Connecticut experiment station when these matters were under consideration, and have also done work since in the Connecticut Valley and in the truck areas of Boston and Providence.

Q. It may be true so far as the machine shops are concerned, and a few other skilled manufacturing industries. Is not the reverse true

so far as the textile industries are concerned?—A. I should say that there is a general feeling among the farm boys in New England that they want the higher education. They want to get into and take up the professions. There is a great ambition on the part of the young men to go to an institute and to get into electrical works at the present time, because the young fellows that they may have been acquainted with are now getting high wages; and there is a desire among the young people of New England, so far as I have seen, to get into these commercial and industrial lines rather than remain on the farms, except where they are situated in communities in which special crops and special agricultural interests are being developed.

Q. Is it your opinion, then, that the system of education in New England is defective—that it tends to work against the best interests of agriculture?—A. That is a very difficult question to answer. It is a notable thing that few of the young men who go to the colleges for their so-called higher education attempt in any way to fit themselves for the farm, and a very striking case of that is found in the small number of students who have attended the agricultural courses at Yale University, which has had a permanent endowment for the purpose of agricultural education, and who have gone out from there as farmer boys. Harvard University maintains an agricultural school and a scientific or technical school, but there is by far a greater attendance at the technical school, as there is at the classical college, than there is at the agricultural courses. This is a question, of course, of the effect of education on farm life, which is widespread; it is found in all schools of the country. My own belief is that the education we are giving our boys is not calculated to make the best farmers, and that we are rather leading them away from the farm. I think there is a tendency the other way now, because we are showing that there are possibilities in agriculture that have never before been realized. We are showing them that there are possibilities of making money, for one thing—of earning salaries that are commensurate in every way with salaries paid to professional men. If we get a tobacco expert now we have to pay $3,000 or $4,000. Six thousand dollars is paid to some of the managers of tobacco estates in the South. The practical growers will willingly pay $3,000 or $4,000 to a man who can manage their estates and make them productive; and the same may be said in other lines of agriculture. In fruit and in dairy interests they think little now of paying $4,000 to $5,000 for experts in different lines—men who can make them successful. These possibilities now are opening up to young men, and they see opportunities for remunerative work. We have recently tried to get tobacco experts in the Department of Agriculture, and it has been necessary for us to pay $4,000 to get a man who is qualified for the work. The Secretary has been desirous of having men trained, and I have presented the matter to several young men, and they have

agreed to come at low salaries, $40 a month—young men from colleges, and they are going to put themselves under the direction of this tobacco expert. They are going into the tobacco sheds and are going to learn how to handle the tobacco, and after they have acquired a practical knowledge they are going to have some training in our laboratories in the principles underlying the handling and manipulation of tobacco. The Secretary says, "Train young men for our own use." If we train them to make good tobacco experts they will go out from us at salaries of $3,000, $4,000, and $5,000, just as we have lost men we have already trained. It is the training, it is the ability of these men to produce products wanted now in this highly specialized industry of tobacco that counts.

The young men are seeing these opportunities, and we are able to get them now readily. They are readily coming to the Department because they acquire in our work an intimate knowledge of the operations on the farm, of the judging and classification of soils, of the treatment of alkali and seepage of waters and underdrainage, and of the production and managemant of tobacco, and we are having no difficulty in getting men who have been trained to some extent. Men are leaving positions in which they were getting $1,000 or $1,200 and coming to us for $40 a month for the experience they will get and the value it will be to them. Some of our young men have had offers at $2,500 or $3,000 to go out and protect some of these Western lands from alkali, because they know how to handle the question. We have shown our ability to handle these questions, which are of so much importance to the people. There is one case which I wish to mention later of a sugar factory in California, that we found was situated on a delta plain. The owners have invested something like $3,000,000 or $4,000,000 in this plant, an immense sum, but their lands are underlain by alkali to such an extent that when they begin to irrigate, as they are planning to do now, there is no question in our minds that they will lose their crops and their lands also. Two factories have been shut up within the last two or three years from this same cause. They know that there is danger, and they offered one of our men a salary of $3,000 just because he knew what the trouble was and could handle that matter for them.

A short while ago Japan took one of our tobacco experts from my own Division and gave him $6,000 to go over there to investigate the possibilities of raising and manipulating tobacco. They came again for another of our tobacco experts and offered him $5,000 to go over and develop the interests on the island of Formosa. These things are having an effect on the people. They are seeing the possibilities in these special industries, and in my opinion the young men are turning more to the farm than they have ever done before, simply because there is something definite, there is a purpose, and they are willingly taking positions in the Department of Agriculture and the experiment

stations, because they are getting into practical knowledge of these affairs. They are acquiring the practical methods and manipulations which give them control of these agricultural methods, and they are finding that they themselves can handle these industries now in a way in which they can make good money, or can get positions of trust and responsibility at salaries commensurate with what are being paid in commercial and industrial lines.

Q. (By Mr. CLARKE.) Are many of these branches of agricultural science capable of being taught in the public schools, say, of the grade of high schools and grammar schools?—A. I think so; and yet it is rather difficult to lay out a course or suggest lines of work and of teaching. But it seems to me, as you have asked me my opinion on this question of education, that we want more agricultural schools, and we want, to say the least, no more agricultural colleges. That is, we want the schools right out on the farm lands where the boys work—where they are taught to care for products and for crops. When I want a tobacco expert I can not go to the agricultural colleges and get a young man who has any knowledge of tobacco. I must go to Florida or I must go to Pennsylvania, and I must pick up an otherwise uneducated man, and yet that man will command a salary of $2,000, $3,000, or $4,000. He is not a college-bred man, but yet he is familiar with the manipulation and the details of that work. Now, if I should want to educate a young man in tobacco lines, to be a tobacco expert or to know how to raise tobacco in the Connecticut Valley, for example, I would take him and send him right to Florida, where they have the highest type of skill and industry in tobacco, so far as tobacco is concerned, of any place in this country. They have developed the industry along really scientific lines by their practical men.

Q. Now, most of the high schools of this country, even in the agricultural regions, have a curriculum chiefly devoted to preparation for entering classical colleges. Almost nothing is taught concerning practical farming in any line. Is it your opinion that the curriculum might be changed to the advantage of the farmer?—A. I think in certain cases it could be, and we would be extremely desirous of seeing in certain centers farming schools for the education of farming boys. If such a school were established in Lancaster County, Pa., under the splendid agricultural conditions prevailing there; if the boys could see the methods pursued there; if they could go out and actually learn how to handle stock, how to handle the soil, and how to handle the crops, they would acquire information in this individual locality that would be admirable in fitting them to take charge of estates and of farm lands of their own in other localities.

Q. Boys reared upon farms become familiar with practical methods, but what opportunity is offered to them in the neighboring schools to become familiar with scientific agriculture? How much chemistry are they taught?—A. There is very little.

Q. What do they know about soiling crops and about the various plant foods and animal foods? Is any of that information taught in any of the high schools in this country that you know of?—A. Very little or none in any that I am familiar with, even in the agricultural districts.

Q. Then, when the system of education leaves the leading industry of a region to the work of ignorance and teaches the youth something else, are they not rather compelled to go out, and are not their ambitions led out into other pursuits?—A. Yes.

Q. (By Mr. PHILLIPS.) At present it would be very difficult to have teachers qualified in these various rural districts to teach this. They would have to be educated for that purpose?—A. It seems to me, further, that when these schools are established they do not seem to be satisfied to remain schools; they so quickly aspire to the dignity of colleges, and from colleges to the dignity of universities. Abroad it is much more frequent to see real agricultural schools, a sort of primary school in agriculture, or high school in agriculture, where the school is situated in a farming district and the methods and thoughts are all upon farming lines. You take a young man and put him under those conditions and he is likely to be much more contented to follow in the pursuits of farming than if you put him into a university like Yale University where the farming course, the agricultural course, is looked down upon by all other students. Under such conditions the young men are not generally satisfied to take a course which is popularly supposed to be an easy one and one which does not maintain the rigorous training that the classical and mathematical lines are supposed to possess.

Q. Perhaps we have diverted you most too long. This is very interesting.—A. I wish I had prepared myself a little more on this line. I did not think of this coming into the discussion. It is a matter that I have often thought of, because I was professor of agriculture in South Carolina and always realized that I was not doing my duty, as it seemed to me, in the training of my men, partly because there is no course in agriculture for a professor to take up—he has to make one himself—and, secondly, the opportunities are not presented, it seems to me, to train people with the particular knowledge that is required in any line of agriculture.

I think that in the New England States, perhaps even more than in the Southern States, that restless desire for material advancement and the higher education has been felt because of the more thickly settled condition and other natural conditions which have already been referred to. Another contributing cause to the tendency in the New England States has been the demoralizing effect of the summer boarders. It seems to me there is no question that, while their presence has been a benefit to the New England States in the main, it

has had a demoralizing effect upon the agriculture of the region. Furthermore, the severe climate of New England has been against the development in some cases, and it has had some effect upon the development of the agricultural resources of the area.

It seems to me perfectly evident that the conditions which have contributed in any marked way to the depreciation of land values in New England have been, first, the development of the West and the lower prices for farm products through the development of the transportation systems, and the increase in the number of factories, in the restless desire of all of our people to a certain extent to leave the quiet and laborious life of the farm and enter the busy, hurried world of commercial and industrial activities. It is quite evident to me, however, that the future for the New England States, as for our Southern States, is in the line of specialization. They are close to the markets; they are peculiarly fitted, as they have already shown, for certain special industries; and the line of future development must be in that direction. They must give up all thought of competition with the general farm crops and must look forward to the building up of certain industries which their position, their locality, and their conditions specifically make possible to be carried on.

The one case of the Sumatra tobacco, that we succeeded in growing last year in the Connecticut Valley, that brought 71 cents a pound when the ordinary crop is grown for 20 cents a pound, was a result of soil-survey work, in which we thought that the conditions were favorable on a certain soil in the Connecticut Valley for the production of this tobacco under certain conditions which we brought about, and the result has been successful. So far as we know, there is no other area besides Florida and the Connecticut Valley, and only certain soils in the Connecticut Valley, where this industry can be pursued; and it is unquestionable in my mind that this industry can be built up, and that there is a possibility of producing $6,000,000 worth of tobacco which we now import from the island of Sumatra every year.

I should also mention that the truck interests and the greenhouse interests around Boston are very great. They are enormous industries, and large amounts of money are invested in them and large profits maintained.

*Maryland and Virginia.*—I come now to the cause of the deterioration and abandonment of lands in Maryland and Virginia.

The exhaustion of the soils, of which we have heard so much in Maryland, Virginia, and the Southern States, is due, unquestionably, to improper and injudicious methods of cultivation and cropping. This will be referred to more at length, under the head of fertilizers, when we come to speak of remedial measures. It is also due to the decrease in value of farm crops, due in turn to the cheaper production in the West and to the reduced cost of transportation, as has been

result is that it is a happy and contented and prosperous community. The lands have been handed down from generation to generation for ages and people seldom think of leaving the place. They are a contented and happy and prosperous people.

In Maryland the methods are altogether different. In the first place the Maryland farm is seldom worked by the man who owns it. There is for some reason an unfortunate prejudice which prevails in many localities, at any rate in Maryland, for a man who actually goes into the field and works his land. He usually has an overseer, a man who is paid to look after and direct his interests instead of doing this himself. Frequently he has not even so much control over his interests, and lets his land out to a tenant farmer who farms it in his own way, by his own methods and for a portion of the crop, and occasionally for a money consideration. The crops grown are the ordinary staple crops of general agriculture. They have corn, wheat, and tobacco. The competition from the West and the low prices of wheat and corn make them scarcely profitable. The competition with the Ohio tobacco and the general specialization which has taken place in the tobacco industry, and the necessity of producing something that is peculiarly adapted to a certain market or to a certain demand, has lowered the price of the Maryland tobacco. Now, after the Maryland farmer has raised these three things he has done, as he thinks, the best he can and he has nothing further to consider for his development. The corn is fed mainly to his work stock, and it all goes to that and his own labor. The wheat is sold and sent off the farm in exchange for flour, which he buys at a considerable increase in cost over what it would have cost him if he could have had it ground in his own neighborhood. The tobacco, of course, is sold and goes out in exchange for productions of all kinds for himself and his family. He buys his meat, he buys his groceries, and he frequently buys the vegetables that he should have raised in his garden.

There is no comparison with the conditions in a prosperous community like Lancaster County and the improvident methods that prevail in some of our Maryland counties and Virginia communities. There is no comparison whatever in the economical methods that are employed, and it seems to me that one of the most important contributing causes to the abandonment and impoverishment of the lands in Maryland and Virginia and of many of the Southern States is due to this one fact, that they do not use the same thrifty methods that have marked the success in Lancaster County and in many other counties of the Northern States.

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Professor WHITNEY (after recess, resuming). At the time of the adjournment or recess I had compared the methods and system of agriculture prevailing in the southern counties of Maryland with the

system prevailing in Lancaster County, Pa., and had drawn some suggestions as to the cause of the differences in the land values in the two localities. In following out our soil investigation and the mapping of lands, we find the same limestone soil which is so productive and valuable in Pennsylvania extending down to the Hagerstown Valley of Maryland and down through the Shenandoah Valley of Virginia. They have the same character of soil, essentially the same climatic conditions; and yet the soils of the valley of Virginia are selling to-day at from $10 to $20 an acre—rarely more than $40 or $50 an acre—while the farm prices in Lancaster County have been maintained about where they were—about as high as they ever have been—and I can not say that this is due to any cause connected with the soil, but conclude that it is due almost entirely to social conditions, to the respect agriculture has in the community, to the thrifty methods employed by the people, and the way in which the occupation is esteemed.

### DETERIORATION OF SOILS OF THE SOUTHERN STATES.

Undoubtedly, the system that prevailed for so many years in the South was satisfactory under the conditions prevailing some years ago, but certainly, with the rapid and phenomenal advance and improvement in industrial lines and in the improvement of transportation facilities, the old methods are no longer applicable. The trouble in this case, it seems to me, is a lack of business method, want of appreciation of changed conditions and of business perception of opportunities that could be taken up and made productive.

In the States farther south than Maryland and Virginia there have been other causes which have operated in this same direction. In the first place, the kind of crop and the clean cultivation that have been given to the cotton crop have caused a tremendous oxidation and loss of the organic matter, and the soil is left relatively poor in these organic substances that are necessary for the normal weathering of the soil material and the preparation of the plant food into a form that is readily available to plants. It has also caused in many areas the erosion and washing of lands that has proved destructive to very considerable areas in the Southern States. There is one condition which has also prevailed against the competition with the South in certain lines of general agriculture—that is, the unfavorable climatic conditions for grain crops. The normal yield of grain in the South is about one-third of what it is in the Northern States. This is due to the fact, so far as we can see, that the greater humidity and larger rainfall are bringing about conditions favoring extensive leaf development rather than the production of grain. In the Northern States the cold, frosty nights are liable to occur about the time the plant has obtained its full development, and this condition favors the production of fruit, as is well known in all life functions. Where there is

danger of the destruction of the plant it tends to reproduce itself in the formation of seed. In the Southern States, with the more equable climate, with the higher temperature, higher rainfall, and generally higher humidity, there is a persistent effort to the production of vegetable growth and a distinctly less chance of the production of grain and seeds. While this is natural, it is by no means necessary, for the largest yield of corn on record is from South Carolina, where there was an abundant growth—abundant vegetative growth—which was checked by methods of cultivation at the proper time—that is, the tendency to vegetative growth being checked, the plant produced seed in proportion to the vegetative growth, and the yield was phenomenal; and it has seemed to me at times as though by a change in the method of cultivation—by some mechanical checking of the growth—that the vegetative growth could be checked and the yield could be largely increased. However that may be, the fact remains that the climatic conditions in the South have never been favorable to a large yield of grain.

I have presented to the commission now the principal causes that operate in the exhaustion and abandonment of soils. These several lines, of course, operate in different proportions in different parts of the country. In nearly all localities one or more of the causes that I have mentioned have operated at the same time to produce the deterioration, if not the abandonment, of soils.

## METHODS FOR RECLAMATION.

I come now to the conditions of reclamation and certain recommendations that it seems desirable to make.

Q. (By Mr. PHILLIPS.) Before proceeding with that I should like to bring up a question which has been touched upon. You said in the early part of your testimony that in England the soils had not deteriorated; that the growers raised about the same amount on the land in the last twenty years as they had for forty or fifty years—about 15 bushels. Is there anything in the climate favoring England in this respect? Would the climate in Virginia and Pennsylvania have the same power or force? Is it on account of the damp, or are the climatic conditions there different from ours?—A. Yes; the climatic conditions have a great deal to do with it.

Q. Then you would not, therefore, claim that 15 bushels could be raised on good wheat land in Pennsylvania, as is the case in England?—A. No; but what I say is that under given climatic conditions and with a given soil, a soil even without fertilizer, there would be a certain grain yield that would be maintained for a good many years; indefinitely, so far as we know. It might be 5 bushels to the acre or it might be 10, or it might be 15. It happens to be that under the conditions in England in this one experiment it was 12 bushels.

Q. I know of farms that have become quite poor on the hills because of the water. England being more level, perhaps the conditions would be more favorable?—A. In this experiment that I cite, yes; it was conducted on a level tract.

### FERTILIZATION.

Q. Pardon the interruption and proceed.—A. The first method that I will speak of in the reclamation of lands, although in my opinion not the most important, is the subject of fertilization. The primary object of fertilization is the improvement or adaptation of soils to the cultivation of any desired crop or crops. As I have shown, all soils have a natural fertility which can probably be maintained under any condition of cultivation for an indefinite number of years. Very frequently this natural fertility is so low that it is unprofitable to raise a particular crop, as so little is obtained from the soil that it does not pay for the attention given to it. Frequently, also, on a very rich soil the aim is to force the crop, and we call it intensive cultivation—that is, we may have a soil which will produce a large crop, and yet we want to force it to produce all it can. It is like the fattening of stock. We can produce a fairly good animal on our ranges, but if we take an animal and feed it up with concentrated food mixed in the proper proportions for a good diet we can put fat and flesh on it which will make it far more profitable than if we had depended upon the natural food of the locality. It is so with soils. We can unquestionably force the fertility far beyond the natural limit and far beyond the ordinary limits of crop production. This we see particularly in the truck crops, where the poor, barren sands are highly fertilized and where large crops are grown from what would naturally be considered a poor soil. In this sense the effect of fertilization is a simple addition of plant food to the soil in such form that the crops can immediately use it. But fertilizers have another effect, that of increasing the decomposition of the soil particles themselves—that is, the mere addition of fertilizers of different kinds may increase the weathering power, and the soil itself will disintegrate and decompose under their influence faster than it would without their application.

The specific objects of fertilizing are to obtain an improvement in the texture of the soil—that is, frequently a wet refractory clay can be made more pliable, more easily handled; drainage is improved. Frequently also loose soil may be made more compact and more retentive of moisture. At times also the influence of the fertilizers is felt more in balancing up the ratio. We have in Maryland and Pennsylvania small areas of lands that are derived from the disintegration of serpentine rocks that carry a large proportion of magnesia; and it has been found that where the amount of magnesia is in excess of the amount of lime plants rarely do well and frequently are an entire

failure. In such case the application of lime simply to reverse the ratio and make lime a predominating ingredient in the soil will restore the fertility of the land. Very frequently also, and probably more often even than we now suppose, soil is acid. It has been found that the soils of Rhode Island are very generally acid, and the addition of lime simply to neutralize this acidity will promote the fertility of the land in a very remarkable degree. This same cause of acidity of the soil is found now to be much more prevalent than we have heretofore supposed to be the case. The fertilizers that are commonly available are farm products—that is, stable manures and green manures, which are used to a very considerable extent and are both exceedingly important in the list of fertilizing materials. Then we have the commercial products, such as guano, ground bone, potash, and then the mineral fertilizers other than lime, and then lime, marls, and gypsum. It will hardly be necessary for me to go into the question of the fertilizer laws. As the commission knows, most of the Eastern States have rather stringent laws about the inspection and sale of fertilizers; and this subject has been taken up by the Department of Agriculture with the idea of having a more uniform system of laws, if possible, and with some idea of having national laws for the interstate commerce and trade. I am not at all sure how far this has gone, and I therefore do not feel competent to speak upon it.

Another series of fertilizing agents is found in the bacteria and other ferments. This newly discovered nitrogen is really a pure culture of bacteria, which have, by reason of their activities in the soil, rendered available the plant food—that is, they increase the weathering of the rocks and also add to some extent (we do not know how much) nitrogen from the air, converting it into some form in which it can be used by the plants.

### ROTATION OF CROPS.

Still another method which I would call to your attention by which reclamation of these waste lands can be realized is in the rotation of crops. There is no question whatever but that in general a rotation or a change in the crops grown on soils is of value in preventing undue waste and undue extraction of certain elements of plant food and the undue tendency for cultivation in a particular way, and unquestionably where intelligent rotation of crops can be inaugurated it is one of the most desirable things to do. There are instances, however, in which the same crop has been grown on the same land for many years without any apparent deleterious effect. On the eastern side of the Connecticut River, near Hartford, they have grown the broad-leaf tobacco continuously for 25 years on the same land, and they claim that the quality of the tobacco as well as the yield is as fine as it was at the beginning—even better.

Q. Is that done without fertilizing?—A. No; that is with fertilizing.

Q. (By Mr. FARQUHAR.) Why is it that the tobacco soils of Virginia here are almost worthless to-day for raising anything?—A. The deterioration of the tobacco lands of Virginia is due more to the general methods of cultivation, which have not looked forward to the maintenance of the fertility of the land or to the proper physical conditions. You will find it almost universally believed in Maryland and Virginia that tobacco is a very exhausting crop and has ruined their soils. On the contrary, if you go to Ohio, or Kentucky, or Pennsylvania, or Connecticut, you will find that it is the one crop which they value as a renovator for their soil. This is, in my opinion, due to the fact that they take so much care of their tobacco lands. They cultivate them so carefully, so perfectly, and so thoroughly; they fertilize them so heavily in order to maintain a good yield and a good quality, that the land has actually improved in spite of the relatively large amount of plant food removed by the crop. I think unquestionably it is a matter of culture rather than of any other one factor. If the Virginia farmers took as good care of their land as they do in other localities there would be no suggestion of deterioration of their soils. But they plant tobacco with little or no fertilizer, or manure, usually without much organic matter. They give the land a clean cultivation and leave it exposed for a considerable portion of the year; and the consequence is that it is not maintained in that vigorous condition in which these necessary changes go on as they should, and the soil is said to be worn out. It is not the loss of plant food; it is a change in the physical and chemical condition of the soil brought about by indifferent methods of cultivation.

### SPECIALIZATION OF CROPS.

One of the most important methods for the reclamation of abandoned and exhausted lands is in the specialization of crops. By this I do not mean the exclusive growing of one crop without regard to all other conditions, but I do mean the adaptation of the particular crop or crops that the land is best suited to, and specialization in that particular industry. I shall cite in support of this position the truck industry, which has reclaimed vast areas of lands in the Atlantic States. Twenty-five or thirty years ago the sandy soils along the Atlantic coast were worth about $1 or $1.50 an acre. I remember myself well when they were worth no more than this. By the introduction of the truck crops—that is, the growing of vegetables for our early markets—those lands have risen in value until now they are the most valuable soils in those States, selling anywhere from $50 to $500 an acre, according to their location with regard to the water, freedom from frost, and in regard to the markets and transportation facilities.

Q. (By Mr. PHILLIPS.) You do not mean in the primitive state, but

that under a state of cultivation they are worth that amount?—A. Yes; I mean that the same land that was worth $1 an acre is now worth $100.

Q. By reason of cultivation, and not in the natural state?—A. In the natural state. Any soil that is suitably located for truck farming, especially near the water, and where there is a freedom from frost and where the transportation facilities are adequate, is worth that in its natural state.

I should also state a similar fact as to the case of the pineapple industry in Florida. There is a narrow strip of sand along the coast in the southern part of the peninsula of Florida that was formerly comparatively worthless. It is simply beach sand thrown up by the tide in former times, and is in a ridge about 15 or 20 feet high. It is white, like glass sand, and to the Northern farmer would be just as barren and unpromising as anything could be. By the introduction of pineapples these lands have been redeemed, and a very fine variety of pineapple can be grown upon them. They are worth now anywhere from $200 to $1,000 an acre, according as to whether they are set in pineapples or whether they are wild lands. Even the wild lands, covered with the native jungle, will sell now for from $100 to $200 an acre when favorably located. I know of no more striking illustration of the possibility of specialization in the reclamation of waste and abandoned lands than this instance of the pineapple industry of Florida.

Q. Are they fertilized?—A. Fertilized very heavily. The sand is used simply as a medium apparently for the fertilizers that are put on. They would be of no value for general crop, but are of exceptional value for this one crop, because there is no other soil which can compare with them in the possibilities of growing pineapples of the superior quality that is grown on them.

Q. That strip is in the southern portion of the State, is it not; below Palm Beach?—A. Just above Palm Beach. It begins about there. It extends from Jensen down to Palm Beach.

I would also cite the case of the bright-tobacco industry in the South. Many areas that were formerly of little value and considered very unproductive have been developed by the introduction of that industry and are now worth more than they were formerly, and are the most productive and valuable lands in that section. In this case, also, it is a special adaptation of a particular kind of crop to a particular soil. The bright tobacco can not be grown successfully on all soils. It is confined to certain soils with certain peculiarities, and they happen frequently to be conditions which are unfavorable for the general agricultural crops, fortunately.

I would cite another instance of the cultivation of tobacco in the Connecticut Valley. On the light, sandy soils a fine grade of wrapper leaf is produced which can not be grown on the tobacco lands of

Pennsylvania or of Maryland. It is confined to that one locality of the Connecticut Valley and the Housatonic Valley, and is a special industry that seems to be adapted to that place. The introduction in 1865 of the Sumatra tobacco from the island of Sumatra has had an effect upon the tobacco industry of the Connecticut Valley. The fine texture and fine veins and the working qualities of this Sumatra tobacco have been so appreciated by the cigar manufacturers that it has been imported in increasing amounts ever since in spite of the revenue duty of $1.85 per pound on all that is brought into this country. In other words, the cigar manufacturers prefer paying $2.50 or $3 a pound for Sumatra tobacco to paying 18 cents or 20 cents for the Connecticut leaf, although, as far as quality goes, the Connecticut leaf is preferred by many. Now, it has seemed to me that the industry in the Connecticut Valley was threatened. The trade wants this Sumatra type of tobacco, and have been giving but a low price for the Connecticut leaf. One dollar a pound is paid for the Sumatra and $1.85 a pound is paid as duty upon it. We take only the best that they have, and there is more and more a feeling against the use of the domestic leaf.

Realizing this condition and the necessity of successfully competing with the Sumatra tobacco, the Department of Agriculture two or three years ago looked around for the possibility of raising a Sumatra tobacco in this country which would prevent the importation of such large quantities from that island, and we decided to try a particular soil in the Connecticut Valley.

Last year we procured some Sumatra seed and planted it under a shed. This shed was erected at a height of about 9 feet, and was covered with cheese cloth so as to partially protect the plants from the sun and maintain a very quiet and humid air. The tobacco was grown and cured by the methods used in Florida and in Sumatra and Cuba—a combination of the different methods—and it was pronounced by experts in New York and Philadelphia to be fully equal to the Sumatra leaf that is imported. We confidently expect to be able to establish an industry in the Connecticut Valley upon certain soils adapted to this very fine leaf, in which we hope to be able to successfully compete with the Sumatra tobacco, which we import to the extent of $6,000,000 a year in addition to the duties.

Q. Could it be profitably produced by covering the ground with canvas as you describe?—A. Yes; the profits are good.

Q. Could it be produced without the covering?—A. No; that is necessary in order to change the climatic conditions to get the particular growth that we want. Even with the expense of $500 an acre, which we estimate for the first cost, the profits are likely to be large. We estimate this year $1,400 worth of tobacco from our experimental crop of one-third of an acre.

Q. Have you sought any lands in the South where the climatic conditions would be somewhat similar to those of Sumatra without the canvas?—A. Yes; some Sumatra leaf is being grown in Florida, and the growers are getting large yields. Their finest wrappers are bringing from $2 to $4 a pound.

Q. They raise it, then, without canvas?—A. No; with canvas there also. The climatic conditions during the growing season are not very different in Connecticut and in Florida. It is the same hot, tropical weather.

Q. (By Mr. CLARKE.) Is that cheese cloth strong enough to protect the leaves from hail?—A. There is no ill effect from hail, except possibly an exceptional storm. There is no injury from wind or from insects or worms of any kind. The protection is carried all the way down the sides. There is a gate with an opening for men and teams. It is entirely covered with canvas, and it is a perfect protection against all extraneous conditions.

Q. (By Mr. PHILLIPS.) It would be liable to destruction by storm, would it not?—A. In a very severe storm such as they had two or three years ago in Florida, where one of those Gulf towns was destroyed by the floods that came up, they were destroyed to a considerable extent; but ours in the Connecticut Valley last year withstood the most severe storms. Any ordinary storm has no effect on it.

Q. (By Mr. CLARKE.) Can you give the expense of constructing and maintaining these canvas coverings?—A. The first cost is between $200 and $500 an acre. That seems rather a wide margin, but it depends on the cost of the lumber. In the South, where they have the sawmills right on the place and where lumber is cheap, it costs about $200 an acre for the shed. In the North it will not exceed $500 an acre, and the shed will last about five years. The cheese cloth will cost about $100 an acre, and has to be renewed each year.

Q. (By Mr. PHILLIPS.) Is it taken down in the winter season?—A. The cheese cloth is hardly worth preserving.

Q. (By Mr. CLARKE.) Are those coverings for each row or are they broad enough to cover several rows?—A. The covering goes entirely over the field. It is 9 feet high, so that horse cultivation is carried on under the shed just as it would be in the open air. It may be a 10-acre field or it may be a 30-acre field, but the entire field is covered.

Q. Like a great greenhouse, then?—A. It has the effect of a great greenhouse. The sunlight and the sun heat is very much reduced and modified, and the air is a stagnant and moist air, humid, because there is no wind to carry off the moisture or change the air. The conditions there are really tropical. The plants keep on growing, and in the Connecticut Valley they went right up to the top of the roof; that is, they were 9 feet high.

Q. (By Mr. KENNEDY.) What is the ordinary height of tobacco plants?—A. Ordinarily, about 4 feet.

Q. (By Mr. PHILLIPS.) This cheese cloth does not prevent the rain going through?—A. No; it does not prevent the rain, but it does prevent evaporation, and it conserves the moisture so that the crops do not suffer as much from drought as they do on the outside. It is also a protection against frost. Indeed a covering of the kind described has been used very successfully in the cultivation of pineapples in Florida to protect them against frost. It seems to be a method that is coming into very extensive use in the protection of crops under intensive farming. In the production of truck crops it is getting to be used extensively to protect them from frost and to maintain humid conditions and protect from drought on the sandy soils.

Q. In a very large per cent of these the flavor is due to the direct rays of the sun. For instance, strawberries would not be marketable raised under such conditions?—A. No; I should not think strawberries would. There is some sunlight under the cloth covering, but it is not so intense. It is the intense sun in the middle of the day that hurts some of our tender vegetables, unless they have plenty of moisture. Covered, they have the sunlight, but it is diffused and not so intense as it is outside.

The commission is well aware of the important part celery has played in the reclamation of many areas of formerly wet, mucky lands in many parts of the country; also the importance of the fruit industry in the reclamation of what we considered worthless or abandoned lands.

The introduction of peach culture in western Maryland has created an industry there on some of the soils which were formerly of little or no value, and where they are now worth anywhere up to $1,000 an acre. The location and the character of the soil has made it possible to produce a late peach which does not come into competition with the peaches from the Eastern Shore and southern Maryland, and which has a very fine color and a splendid flavor. These soils are of no value for general farm purposes, but they are particularly adapted to the production of peaches which ripen late, and which have a good flavor and a bright color.

The commission is also aware of the success of grapes and vineyard culture on gravelly soils, and it will hardly be necessary to dilate on the importance of this crop as a means of reclaiming such areas. The most valued soils along the Rhine are frequently so destitute of soil covering that they have to be maintained by stonework, and on these very gravelly soils the finest varieties of grapes have been produced. Over a large class of soils, particularly in rocky and stony areas, fruit trees and grapevines have been found a most important means of reclaiming otherwise worthless lands.

There is one consideration, of course, in the production of fruit which must always be considered, and that is the possibility of marketing. That problem has been solved to a considerable extent by

the possibilities of marketing the fruit in a dried or canned condition, and the exportation of dried fruit is to-day a matter of the greatest importance, and one that is increasing in magnitude, especially on the Pacific coast, where large and increasing quantities of fruit are being consigned to China and Japan.

### REFORESTATION, PROTECTION FROM FIRES, ETC.

Another important means for the reclamation of poor or abandoned lands is in reforestation and protection from fires and a more rational method of cutting the timber. This is a subject which is being investigated in the Department of Agriculture, where we have our Division of Forestry concerning itself with this one problem; and it is one of the important problems applicable to areas in which there seems at present to be no other means of improving the land.

### THRIFTY BUSINESS METHODS.

The question of thrifty methods and efficiency of labor is one that is very hard to deal with. I can not understand how, by education or by legislation or in any other way, thrifty methods can be introduced into certain areas that are at present of little value simply because the methods are not good. Under present conditions, I do not think that any education would make farming in southern Maryland attractive to a young man. It would be discouraging, no matter what kind of education he had, for him to go back and live under the conditions that prevail there at the present time. The social conditions are such that he can not work with his own hands, and he does not have the intelligent or efficient labor to organize and carry out his ideas. He is confronted from the start with conditions that are almost hopeless for the introduction of new methods and of new crops on a scale commensurate with the importance of the work and the facilities at his command.

Q. Is the negro population very numerous in southern Maryland?—A. It is quite large. It is the principal but not the only labor, and not nearly so large as it is farther south. In my opinion the importance of reclaiming large areas of lands is indicated by the necessity of more thrifty methods and more businesslike plans than they have at the present time in the selection of industries and in the cultivation of crops.

Another very necessary means to the reclamation of lands is business methods and organization in the marketing of crops. The success of the truck industry in Norfolk is largely due to the splendid organization and to the means by which the truck farmers place their crops in certain markets, according as the demand may be greater in one or the other. This is an essential thing in truck farming, because the vegetables can not be held over, but must be marketed or sold as soon

as they reach maturity, and they have to be sold for what they will bring. The organization of growers gets regular daily returns of the market conditions in different cities, and they are able to divide their crops and to send a certain portion to this market or to that, according as they think the conditions will stand. It seems to me that this organization and the introduction of these business methods are the most important factors in the reclamation of abandoned areas and the introduction of new crops.

### IRRIGATION.

The commission is of course quite well aware of the method of irrigation which has been so important in the reclamation of certain areas in the West. Unfortunately, about all of the available water has been already appropriated and is nearly all in use.

Q. (By Mr. KENNEDY.) Is that true? Governor Steunenberg, of Idaho, told me a week ago last Sunday that the possibilities of the Snake River for irrigation purposes were wonderful, saying they had not begun to use the water of the stream up to its full capacity.—A. That is so in certain cases. It is so in the case of the Yellowstone River also. But nearly all of the water in California and in Washington and in certain portions of Arizona and in the Pecos Valley in New Mexico is now used to its fullest extent. There are other areas in Montana and in Idaho and in Wyoming where there is still some available water, but as a general statement it may be said that the available waters are already appropriated and in use, except, as I was going to say, such as may be added by the construction of reservoirs for the storage of waste waters.

Q. (By Mr. PHILLIPS.) There are very large possibilities in that regard, are there not?—A. Yes; it is estimated that about 74,000,000 acres can be irrigated by the construction of reservoirs.

Q. (By Representative BELL.) What are the possibilities of the irrigated soil?—A. They are very great for special crops, but they are not so very great for our general crops. For instance, it no longer pays to irrigate wheat. The principal crops are the fruit crops of all kinds, and alfalfa for stock feeding, and special industries of that kind. With these special industries the possibilities are enormous.

The average cost of placing land under irrigation, as shown by the last census, was $12.12 per acre, and the annual cost thereafter of maintaining the water was $1.07 per acre of the public lands. Newell estimates that 74,000,000 acres are capable of being irrigated. The cost of the opening of this area, taking the average of previous experiments, would be $897,000,000. But as the methods of applying the water to the land heretofore have been the simplest possible, the cost per acre has been much less than the cost will be in the new areas that are to be taken up, where the water must be stored and carried

over long distances. For the storage of water under the most favorable conditions in Arizona Mr. Lippincott estimates the cost at $4.30 per acre-foot, and as at least 5 acre-feet of it must be stored for each acre in order to provide for two or three seasons of low water, the cost would be about $21.50 per acre. I would call your attention to the basis of this calculation. It assumes that all of the land that could be watered by the storage reservoir shall be actually taken up and put under water. If only half of that area is taken up, the cost would be twice as great per acre; if only a quarter, it would be four times as great, and so on. So this cost that is given in the estimates of the irrigation engineers is the cost provided all the land possible should be taken up and put under water and the rate per acre was paid in to the canal company.

Q. What would be the value of this land after it was put under water?—A. It would be from $60 to $100 an acre.

Q. (By Mr. PHILLIPS.) Notwithstanding the cost of maintaining the water afterwards?—A. Yes.

Q. (By Mr. KENNEDY.) In what localities?—A. Through the arid regions. This example was in Arizona. Lands in Utah are worth from $60 to $100 an acre; and, set out in good varieties of fruit orchards, anywhere up to $1,000 an acre. In southern California lands are worth generally from $50 to $100 an acre, but many of their orchards are worth from $1,000 to $2,000 an acre.

Q. (By Mr. PHILLIPS.) That would be when they were fruit bearing?—A. Fruit bearing, yes; in fine varieties of fruit. The difficulties in the way of the extension of irrigation by the construction of storage reservoirs are the alkali and the silt in the water. There is no question that the amount of alkali in the water is a very serious factor in many localities. In the Pecos Valley it has been found that the alkali increases in amount as they go down the valley to such an extent that in the lower part of the valley the water is entirely unfit for crops. In the storage reservoir in which water is stored above the town of Carlsbad the evaporation is so great that the salts become concentrated in the water, and at the end of a long dry season the water is too salty to be applied safely to the land. This region, by the way, has the highest evaporation of any place in the United States—approximately so. Considerable trouble has been experienced also and losses have been encountered by the storage of alkali waters in California, particularly in southern California.

Q. Is that water obtained in the hills and mountains or from the rivers? Do you not get pure water from the mountain streams?—A. Yes; and the water in Utah is very pure because there are short rivers that come right down from the snow-clad mountains and deliver pure water; but in the Pecos Valley the water travels 200 or 300 miles from the mountains and gathers up these salts as it goes along. The Pecos

River is entirely taken up about 6 miles above the town of Carlsbad, and 6 miles below the reservoir the stream has about the same flow that it has above the reservoir. Frequently out in the Western lands the water is entirely used up before it gets down the whole course of the river, going out in seepage and flowing again into the river after it has been applied to the land. By the time it gets down to its mouth the water is pretty salty.

There is another difficulty in the storage of water in reservoirs that is particularly troublesome in some areas in the West; that is, the amount of silt carried by the waters. In our work in Arizona, where the waters are very heavily laden with silt, we found a soil that has been recognized as a distinct type, which is undoubtedly a sediment left by the irrigation of some prehistoric race. The old canal systems are there and the old irrigation works and the remains of the houses, indicating that irrigation was carried on in some prehistoric time, and the evidences show that this is simply a deposit of sediment or mud from the rivers. The amount of sediment is so great that the people now have great difficulty in maintaining their canals. They have already dug it out and piled it up as far as they can throw it, and it is a serious question now what they are going to do with the canals in certain areas of the Salt River Valley in order to keep them open. It is very generally believed that reservoirs will quickly fill up with the silt in such districts as that unless special precautions are taken to keep them open; and that is an engineering feature that has not yet been satisfactorily solved. In other localities there is no trouble with this silt, as the waters do not carry any great amount. Even if we get water that is free from silt and an absence of salt, there is the further danger of seepage waters and the accumulation of alkali in the soils, as I have already stated.

Q. This accumulation of alkali is only in arid countries? There is no alkali to speak of in the Appalachian Range, is there?—A. No; because the drainage is so great. So much rainfall comes down that it is carried off. The alkali is the natural weathering of the rocks, resulting from their disintegration.

Q. Peculiar to arid regions?—A. Yes; although we have it here in the East occasionally. The mineral springs that we have are due to nothing more nor less than the decomposition of the rocks, and the same cause accounts for the alkali in the Western States. It is the weathering of the rocks being carried off by the water. In the West these decomposed rocks accumulate in the soil and stay there. Our iron springs and our alum springs and mineral springs generally are the products of the weathering of the rock being carried off by the water. But we get no such accumulations here as they get in the West, simply because we have 40 inches of rainfall here, 20 inches of which goes down through the ground and is carried off in the rivers.

Out there we have a very small rainfall, only about 5 per cent of which ever goes off, and then usually over the surface of the ground.

In the consideration of irrigation as a means for the reclamation of lands, I would call the attention of the commission to the necessity of uniform State laws and the possibilities of national legislation. There are certain phases of this subject which will undoubtedly have to be taken up by the National Congress, particularly with interstate streams and where the streams form the boundaries of adjoining States. But as the Department of Agriculture has a distinct division for the study of irrigation and its laws and methods, it would hardly be advisable for me to go into it at any great length. My own connection with the matter, however, in our study of the soils and of the seepage waters and alkali has convinced me that it will be necessary to use more care in the application of water, not only conserving it for use elsewhere, but to protect from the injurious effects of overirrigation and the accumulation of seepage water and of alkali. I think it is safe to say that in nearly all the irrigated districts twice as much land could be irrigated with the water that is now used, with actual benefit to the soil, provided it was intelligently applied.

I would also refer again to the matter that I spoke of a while ago; that is, the necessity of legislation in the case of soils damaged by the accumulation of seepage water and of alkali from leaky ditches and from overirrigation on neighboring farms. It seems to me that a remedy of some kind must be worked out. It hardly seems fair or just that a person owning a piece of land which he has planted and cared for and upon which he uses the most careful and most intelligent means, should be allowed to be injured by a seepage from a canal or from the careless methods employed on a neighboring farm. It seems to me that either through State or national legislation recourse should be given for the recovery of damages in civil suits.

## DRAINAGE.

The next method to which I would call your attention for the reclamation of lands is the subject of drainage. There are many areas of swamp lands and still larger areas of cold, wet clays in the United States that are unproductive or have been abandoned from a small accumulation of water which needs to be removed by artificial means. It is claimed that one-fifth of the State of Michigan is swamp lands. The report of the Illinois board of agriculture for 1894 states that during 1893—that is, in one year—there was laid in the State of Illinois alone 26,985,000 feet of tile drains. Of this, 18,310,000 feet were laid in the northern part of the State, 8,607,000 feet in the central part, and the remainder in the southern part. In the north there were 28 feet of tile to each acre cultivated. In the central part there were 29 feet of tile for each acre cultivated, and in the southern

part 1 foot of tile for each acre cultivated. In Douglas County there were 85 feet of tile for every acre of cultivated land, and in Livingston County 78 feet to each acre. In the eastern part of Livingston County is found the Vermilion Swamp. As late as 1880 lands could be purchased there for $3 to $5 per acre; the same lands, which have since been drained, are now valued at from $60 to $90 per acre for general farm purposes. As a result of this widespread system of drainage as practiced in Illinois and in Michigan, the swamp lands have become the most productive, the healthfulness of the vicinity has been much improved, and the public roads have been kept in much better repair. The drainage laws of Illinois, and in fact of most of the States where drainage is practiced to a considerable extent, are very complete and deal with all phases of the question, from the rights and liabilities of the drainage commissioners of the district down to the minute details which concern the individual. It seems to me that this question of drainage legislation is one of the important questions, at least for the Western country.

Q. What State has the best laws as to drainage?—A. My opinion is that Illinois has the most complete; Illinois, Michigan, Ohio, Wisconsin, Minnesota, and New York.

As a result of our soil investigations in the Salt Lake Valley last year, we found that it would be quite possible to reclaim the large tract of salt land west of Salt Lake City, and perhaps that this should be done by the people; but it was apparent in the first place that if it were done it would have to be done by private enterprise, as the State was debarred by its own constitution from taking any part in internal improvements of that character, as is done in Minnesota and in some of the Central Western States. It was further found that, by reason of the lack of any drainage laws, it would be almost impossible to drain any considerable part of that area without getting the written consent of every individual landowner who would be in any way affected; and strange as it may seem, it was not found possible to get such consent in the attempts that have been made.

### PROTECTION BY LEVEES.

Another method for the protection and reclamation is by levees for protection from floods and from tide. The commission of course is aware of the important work of the commission having this matter in charge on the Mississippi River, and it is scarcely necessary for me to refer to it at this time. I have also spoken at some length in regard to the levees protecting the rice swamps of South Carolina and adjoining States.

A question that is assuming some proportions now in this country is the possibility of reclaiming the swamps of the Atlantic and Pacific

coasts. Not only is it desirable to reclaim these lands for their agricultural value, which it is admitted would be great, but for the protection, the help, and the material welfare of the surrounding country. We have a very excellent illustration of the tremendous bearing this question has upon the healthfulness and prosperity of a community by reference to the conditions prevailing here in the city of Washington, where the swamps have rendered almost uninhabitable, at least by the wealthy and well-to-do people, certain portions of this city, and where there is no possible question that the cause could be removed, and an appreciation of property aggregating thousands and thousands of dollars could be effected simply by reclaiming the swamp lands.

Q. Have you any method of or any theory concerning the reclaiming of those lands? The tide comes up the Potomac. How can it be prevented from overflowing?—A. The same method would have to be used that is used in the rice lands of the South, where similar conditions prevail. There should be a levee with gates which will let the water out and drain the land, and will shut when the tide comes up and prevent any access from the outside. With that protection against the rise of the tide, accompanied by the necessary drainage in the soil itself to carry off the seepage waters which come from the surrounding country, the land could be reclaimed and put in a high state of cultivation.

This question has been asked in regard to the possibilities of reclaiming many of the marshes of Long Island and of New Jersey particularly. It has been estimated that the reclamation of the marsh lands in New Jersey adjacent to Jersey City would cost something like $3,000,000. The plans are under consideration now, and, in fact, large areas have already been undertaken in the reclamation of those lands. Also along the coast, particularly in connection with the residents on Long Island and along the Jersey coast, in Delaware and in Maryland, and in North Carolina and in Virginia, the disastrous effects of these swamps are keenly felt by the people who go there to spend the summer near the seashore. Not only are they unpleasant, but they are at times and in places distinctly dangerous because of the prevalence of mosquitoes, which convey malaria, and because of the presence of other fevers that are very fatal or injurious.

A plan has recently been proposed to the Department for the reclamation of a large area of swamp land on Long Island for the purpose of being able to treat the swamp for mosquitoes. They are not able without enormous expense now to control the mosquito pest and the consequent malaria that has come to the locality. They want to see if the land can be diked and subsequently drained, so that they can entirely exterminate the mosquitoes from that locality. It is probable that the plan will be carried out.

It seems to me that such work as that is primarily for the individual

and in the second place for the State. I hardly see that the National Government has any interest or control in the matter. It is certainly not like the development of harbor privileges or the improvement of rivers, for it applies only to the locality in which it is conducted.

Q. (By Mr. CLARKE.) Are you aware of the experiment in reclaiming marsh lands that was made in Marshfield, Mass.?—A. Not particularly.

Q. There the dike had the effect to close the harbor, practically; not but that there was sufficient area of harbor below the dike, but the failure to accumulate a large body of water above that checked the passing out with the ebb of the tide, and resulted in the accumulation of sand bars in the lower harbor, so that the harbor was practically ruined, and there was a great clamor on the part of the fishermen, which finally came to be supplemented by that of cottagers who built along the shore of that small bay, until, finally, the legislature was induced to cut away the diking and abandon the experiment of reclaiming the lands.—A. Oh; it was the outflow of this immense volume of water that filled up the channel?

Q. Yes; so I apprehend that whenever the experiment is entered upon along the shore anywhere to reclaim the marsh lands the question of harbor rights and the like will come in to affect the problem more or less.—A. There is no question that legislation will be necessary, and it is likely to be a complicated matter. It is one that would affect the State, however, and not the National Government, unless it interfered, of course, with the channels of the harbor; then it would be a national matter.

I think that I have covered in these remarks the principal causes of the exhaustion and the deterioration of soils, as I view the question, and I have spoken at some length in regard to measures which should be used for the reclamation of lands. If I have left anything unsaid that should have been said, or if I should have made anything clearer, I should be very glad to answer any questions that the commission may be pleased to ask.

Q. You said something about animalcules in the soils. Is that a comparatively recent discovery, or has it been long known to scientists that soil abounds in animal life?—A. It is comparatively recent, that is, within thirty or forty years, that the bacteria have been recognized and their importance understood.

Q. I have seen a statement that you can take a small tract of soil which is very fertile, and accustomed to produce large crops, and strike it with a pole persistently until you kill all the animal life that there is in it, and that the next year it would not bear anything. Is that correct?—A. I do not think so; I do not think it would be possible to kill bacteria in that way.

Q. (By Mr. PHILLIPS.) You spoke of cultivating bacteria. What process is used?—A. Certain leguminous crops have tubercles on their

roots, which are found to contain large numbers of these bacteria, and by inoculating with this suitable culture medium, they can be cultivated and pure cultures be made. Such cultures are for sale in Germany and to a limited extent in this country, and it is found that certain crops will not grow unless these bacteria are in the soil; therefore many of the leguminous crops, for example clover, will not grow unless there are certain forms of these bacteria in the soil, and by seeding this pure culture over the land, that is, mixing with a little soil, and sowing on the land, the yield may be doubled, or increased even more than that.

Q. The small bulbs are used in producing cultures in the same way?—A. Yes; the tubercle is just mashed in the culture medium, so that the inside is exposed, and these bacteria get out and thrive on this culture medium.

Q. What is used for that culture medium?—A. I am not sure what is used; I am not acquainted with the method of making the pure culture.

Q. (By Mr. TOMPKINS.) That is similar to Conn's culture in giving flavor to butter?—A. To butter or cheese.

Q. Where is this culture made in this country?—A. Some important experiments have been made at the experiment station in Alabama.

Q. At Auburn?—A. At Auburn; yes. Some of the most important work has been done there.

Q. Under whose charge?—A. I do not recollect now.

Q. (By Mr. CLARKE.) Can you ordinarily determine by the examination of soil what is requisite to make it more productive?—A. No; you can not, and that is one of the most embarrassing questions that we have to answer. As I have shown in my testimony, the cause of the deterioration is quite often due to lack of good management, good judgment, and good practice on the part of the farmer, but we can not tell from a chemical or physical examination whether the soil is productive or not. We can often tell the kind of crop it is adapted to, whether it is a truck soil, or wheat soil, or a grass soil, but whether it is fertile in its condition the chemical analysis does not clearly indicate.

Q. Recently Mr. Hammond, of South Carolina, a very intelligent planter of long experience, testified before the commission that in his opinion the use of commercial fertilizers was an evil rather than a benefit, especially in his State, and particularly because it led many farmers to abandon making an application of the ordinary farm fertilizers, manures, etc. What is your opinion about that?—A. My opinion is that in the main that is correct; that the use of fertilizers tends to make the farmer more shiftless and less careful in saving and in the cultivation of his land. Fertilizers have been introduced in comparatively recent years. There was never any trouble for lack of fertilizers in the Eastern countries. The lands there have been culti-

vated for hundreds and thousands of years, but it had been done by careful work. The farmers have saved everything that came off the place. They have saved all of the litter and put that back; all manure and put that back, and all excrements and waste of the farm and put them back on the soil and worked it in; they have had small holdings and used intensive cultivation. With us, we have these large areas, entirely too large to manure with the ordinary waste from the farm, and we rely on these commercial fertilizers with no addition of organic matter, and after with clean cultivation. There is no question in my mind that much harm has been done by continuous and excessive use of commercial fertilizers without the intensive methods that should be employed when they are used.

Q. Would it not, in your opinion, be possible to reclaim very many of the so-called worn-out farms of Maryland and Virginia by gathering muck from the low places and subjecting it to the tread of live stock, and mingling with it the manure that ordinarily accumulates on a well-stocked farm, and applying that intelligently to the various soils of those farms?—A. It would be where the cost of the process would not be too great, but unless it was adjacent to the land it would not be feasible. The cheapest method in that case would be to grow cowpeas and other forms of green manure. There is no question if you adopt such methods as that, of being able to bring the land up. It is simply because farmers do not do what they know is the simplest and most efficient thing to do. There are lands that are kept up in good shape just by the methods that are used on the average farms which are in very good condition, simply because they are attended to in those ways.

Q. Have the farmers of the West begun to practice fertilization a great deal more than formerly?—A. They are not using fertilzers to any great extent. I think the practice is increasing a very little, but very little fertilizer is used throughout the West at the present time.

Q. Is there not danger that their soils will become comparatively barren unless something is done to restore what is taken from them?—A. There will be if the owners persist in the cultivation of the same crop year after year, as is done now in Red River Valley and in some of our Central States; but by a rotation of crops or by introduction of more intensive methods when the soils begin to wear out their fertility can be maintained and improved. Now, they say very justly that while they are getting 12 or 15 bushels of wheat to the acre at the low cost at which it is produced, 20 cents, they don't care at all what becomes of their lands; they are going to last the lifetime of the present generation and they are not concerned with what becomes of them after that. I think very likely that that yield of 12 or 15 bushels that is obtained now in the Red River Valley can be obtained for a long series of years. The soils are almost identical with the fertile wheat lands

of Russia that have produced wheat for a great many generations, but the time will come, I presume, when the yield will decrease below what they are getting now, and they will feel the need either of fertilizing the soil better or of changing their crops and introducing more intensive methods than they have at present.

Q. What is your advice on the subject?—A. I see no opportunity of changing the methods at the present time. It is a good deal like the arrangement made where you can rent range lands for 5 cents an acre per year, and where you can not afford to put much improvement on the lands. They are only worth $1.25 an acre, and you certainly can not spend much money in maintaining the fertility of such lands. It seems to me it is an economic question; it is not an agricultural question. We simply can not afford to maintain the fertility of those lands with the expense attending that process until lands become more valuable than they are at the present time.

Q. It is cheaper, is it not, to maintain fertility than to restore it?—A. That, of course, is a relative matter; it is more expensive for us and it is less expensive for our grandchildren.

Q. Have you investigated the subject of flowing sewage upon the lands?—A. I have not, except quite incidentally. We have never made any investigation of that question at all.

Q. (By Mr. PHILLIPS.) What is the best green crop to raise to fertilize the land—plowing it down, for instance?—A. Clover is one of the best renovators of the soil where it can be grown, but the possibilities of growing it are limited and the most generally useful crop is the cowpea of the South.

Q. That came into use quite recently?—A. Yes; well, twenty-five years ago in an extensive way.

Q. Is it used to a considerable extent in the North and West?—A. It is being used to a considerable extent now in the North.

Q. It is supposed to have this bacteria, is it not?—A. Yes; it has these root tubercles.

Q. (By Representative BELL.) Have you ever visited Greeley in Colorado?—A. I was there once, six years ago.

Q. They have a rotation there on first wheat; then they follow with alfalfa, which they plow under; then follow with potatoes, and in turn follow the potatoes with wheat. They thus grow an enormous crop every year. I think they make over 40 bushels of wheat there to the acre following those crops.—A. And they get enormous yields of potatoes.

Q. Enormous. It is the best potato spot in the world. They haven't a rival in the United States. I think they ship the best potatoes to London.

(Testimony closed.)

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U. S. DEPARTMENT OF AGRICULTURE.

Report No. 71.

# SOME MUTUAL RELATIONS BETWEEN ALKALI SOILS AND VEGETATION.

BY

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*Division of Vegetable Physiology and Pathology,*

AND

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1902.

# LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY,
*Washington, D. C., June 24, 1901.*

SIR: I have the honor to transmit herewith several papers on Some Mutual Relations between Alkali Soils and Vegetation, prepared by Mr. Thomas H. Kearney, of this Division, who was detailed to the work at the request of the Chief of the Division of Soils, and Dr. Frank K. Cameron, of that Division, and respectfully recommend their publication as Report No. 71 of the Department. The studies so far made in connection with the work discussed in these papers have brought to light some important facts and have opened lines of inquiry which promise to develop methods of dealing with alkali soils that will reduce their injurious effects on crops grown where such soils exist.

Respectfully,

ALBERT F. WOODS,
*Chief of Division.*

Hon. JAMES WILSON,
*Secretary of Agriculture.*

# LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF SOILS,
*Washington, D. C., June 24, 1901.*

SIR: I respectfully submit herewith the manuscript of a report prepared by Mr. Thomas H. Kearney and Dr. Frank K. Cameron to throw light upon problems encountered by the field parties of the Division of Soils in the soil survey of certain areas in the West affected with alkali. As this is treated largely from the physiological side, it seems proper that it should be transmitted by you for publication.

Respectfully,

MILTON WHITNEY,
*Chief of Division.*

Mr. ALBERT F. WOODS,
*Chief, Division of Vegetable Physiology and Pathology.*

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# SOME MUTUAL RELATIONS BETWEEN ALKALI SOILS AND VEGETATION.

## THE EFFECT UPON SEEDLING PLANTS OF CERTAIN COMPONENTS OF ALKALI SOILS.

By THOMAS H. KEARNEY and FRANK K. CAMERON.

### INTRODUCTION.

Everyone who is familiar with alkali soils knows that their charac ter varies greatly in different localities, one salt or combination of salts predominating over others which may be present.[1] Sometimes sodium carbonate, the dreaded "black alkali," is relatively abundant as compared with the other soluble soil components. In other cases this salt may be entirely absent or present merely as a trace, while one or more of the "white alkali" salts, e. g., sodium chloride or sodium sulphate, plays the most important part.

It is also known that these salts are not all equally injurious to vegetation. Sodium carbonate, for instance, is generally believed to be much more harmful than any other salt of common occurrence, owing probably to its pronounced corrosive action on the plant tissues. Gypsum, or the dihydrate of calcium sulphate, on the other hand, is harmless and even beneficial in ordinary cases. Experiments with solutions of chemically equivalent strength show very marked differences in the action of different salts upon plant growth. Hence the question whether the salt forming the greater part of the soluble components of a given soil is, to take a concrete case, the very injurious sodium carbonate or the relatively harmless sodium chloride, may often determine whether that soil is utterly useless or quite valuable to the farmer.

It becomes, therefore, a question of great importance to everyone who is concerned with soils which contain an appreciable amount of alkali to know definitely the relative harmfulness of the salts both severally and in mixtures, since the latter is the condition under which they almost invariably occur in nature.

Field observations will give some idea of how the soluble salt components compare in this regard. But the conclusions are necessarily somewhat vague and unsatisfactory; for in the field and under the conditions that are found in nature it is practically impossible to study

[1] See Bulletin No. 17, Division of Soils, U. S. Department of Agriculture (1901).

the effect of any one soil component. It is rare indeed that the "alkali" is composed of but one salt or chemical individual. And, as will be brought out later, it is entirely impossible to predicate anything definite as to the action of a mixture of salts upon a plant from a previous knowledge of the effects produced by each single salt. Conversely, it is equally impossible to draw conclusions as to the action of any one of a mixture of salts from observations of the effects produced by the mixture itself.

The more exact methods of the laboratory are necessary in order to give us precise knowledge, and with this end in view the present investigation was undertaken. It is not claimed that the results so far obtained are in all respects conclusive. The fact that only two species of plants were employed in these first experiments is sufficient indication that they are not. In physiological research nothing is more dangerous than generalization from the behavior of one or a few species of plants to that of plant life as a whole. It is a well-established fact that species differ widely in their reaction to a given chemical or physical condition. Witness the fact that seaweeds will thrive in water containing 1.5 to 3 per cent of sodium chloride, and that salt marshes, whose soil is saturated with water containing nearly or quite as much of this salt, often support a luxuriant vegetation, while the average crop is killed by a much more dilute solution of sodium chloride. Certain plants show a marked aversion to limestone soils, while other species are almost entirely limited to soils having a high content of lime.[1] But it is needless to multiply illustrations of so familiar a phenomenon.

That a similar diversity is manifested by different cultivated crops in their sensitiveness to various mineral salts when present in the soil solutions is well known. Therefore we can not safely predict, until experiments with many different plants have been made, that the order of harmfulness of the alkali salts here established for two plants will be found to hold for all or even many of those which are commonly cultivated in the alkali regions. But, as it is obviously essential to the satisfactory prosecution of alkali soil work that a definite standard for comparison of the salts be established, there need be no further apology for the presentation of these first results of what it is hoped will become an exhaustive investigation.

In the progress of the work numerous data were accumulated which appeared to possess a more than ordinary degree of scientific interest, especially as relating to the chemical theory of the dissociation of electrolytes in solution and to the recently published hypothesis that various salts, or rather their dissociated ions, enter into compounds

[1] The interesting subject of "lime-loving" and "lime-avoiding" plants has been much discussed by European botanists. It is synoptically treated by Drude (Handbuch der Pflanzengeographie, p. 51) and by Schimper (Pflanzengeographie, p. 105). The latter author gives an extensive bibliography.

with the proteids of the protoplasm of plants and animals, which "ion proteids" play a highly important part in life processes and phenomena. This aspect of the subject will be treated particularly in discussing the significance of the experiments with mixed solutions.

## METHODS OF EXPERIMENT.

### SALTS EMPLOYED.

In the selection of a series of salts for investigation the experience of members of the Division of Soils in field and laboratory served as a guide. Salts were used which have been determined as forming definitely injurious components of alkali soils and as occurring in sufficient quantity to be of practical importance. In about the order of their general abundance in the Western United States these are sodium chloride (NaCl), sodium sulphate ($Na_2SO_4$), sodium carbonate ($Na_2CO_3$), sodium bicarbonate ($NaHCO_3$), magnesium chloride ($MgCl_2$), magnesium sulphate ($MgSO_4$), and calcium chloride ($CaCl_2$). Incidentally, experiments were made with gypsum ($CaSO_4 2H_2O$), calcium carbonate ($CaCO_3$), calcium bicarbonate [$Ca(HCO_3)_2$], and with magnesium carbonate ($MgCO_3$), and bicarbonate [$Mg(HCO_3)_2$], as well as with an aqueous solution of carbon dioxide ($CO_2$), the last in order to test a theory that suggested itself during the experiments with carbonates and bicarbonates.

In preparing and standardizing the solutions much assistance was rendered by Mr. Seidell, of the Division of Soils.

The solutions were invariably made with salts manufactured by Baker & Adamson, and found to be practically chemically pure, dissolved in distilled water.[1] They were made up in each case on the basis of a normal solution—i. e., of a gram-equivalent per 1,000 c. c. of

[1] The water used in all experiments was distilled through a tin worm and was collected and stored in Winchester quart bottles of practically insoluble glass. A conductivity test showed this to be an unusually pure water, but in order to establish this point beyond doubt, a portion of this same water was redistilled from glass, the first and last portions being of course discarded. A test of the distillate showed it to possess about twice as great conductivity as that which had been distilled only once from the tin. A comparison of cultures of lupines in the water which had been only once distilled with that which was redistilled showed practically no difference in the amount of growth made by the roots. As Galeotti has lately shown [Biol. Centralbl., 21, 329 (1901)], the oligodynamic action of relatively concentrated "colloidal" solutions of metals disappears in the presence of weak solutions of electrolytes. Thus a solution of copper containing 1 gram-atom of metal per 126,000 liters of water produced no effect upon Spirogyra in the presence of a 0.01 per cent solution of sodium chloride, and a solution of 1 gram-atom of copper per 63,000 liters of water acted only after twenty-four hours, although in the absence of the electrolyte the toxic effect of the colloidal copper solution is manifested at a dilution of 1 gram-atom of copper per 126,000,000 liters of water. (See footnote, p. 50.) Hence it is practically certain that in the experiments described in this report no complications were to be feared from the possible presence of a trace of metals in the water used.

solution. In other words, in the case of monovalent compounds, one gram-molecule was contained in a liter of solution, while in the case of bivalent compounds, a half gram-molecule was present.[1] In this way only is a really instructive and fair comparison of the effects of different salts obtainable. Many experiments made in times past in which comparisons were based upon simple percentages of solute to solvent by weight are for this reason of far less value than if normal solutions had been employed. In order to study comparatively those effects produced by different electrolytes which are not dependent upon their respective chemical natures, but which are common to them all and due only to their active masses (such, for instance, as effects due to the osmotic pressure existing in the solution), it is obviously necessary to take into consideration the number of reacting weights of the electrolyte introduced and the amount of electrolytic dissociation which takes place. That is to say, one must consider the concentration of the solution with respect to the number of reacting chemical equivalents, molecules, or ions which may be present. Moreover, attempts to study comparatively the effects produced by different kinds of ions in the solution can only be made by approaching the subject in this manner. But in all statements in this report of the concentration of a given solution both fractions of a normal solution and parts of salt to 100,000 of solution are given in order that the results may be readily intelligible to readers who are familiar with one or the other method, as the case may be.

The method pursued in these experiments was to make and carefully standardize a large volume of a normal solution of each salt and then dilute to the required strength as occasion demanded.

In beginning the experiments the limit for each salt as determined by investigators in the field was first tried, but immediately showed itself to be too high. So lower and lower concentrations had to be tested until the critical one was reached.

### PLANTS SELECTED FOR EXPERIMENT.

For a variety of reasons the white lupine (*Lupinus albus*) was employed in nearly all the experiments, although subsequently alfalfa (*Medicago sativa*) was introduced for comparison. The lupine has a seed of good size, averaging 10 to 12 mm. in greatest diameter. As an abundant supply of nutritive material is stored in the thick seed leaves, there is no danger of starvation of the seedlings in experiments of short duration such as those here described. The lupine seeds germinate readily, sending out a vigorous radicle with clean,

[1] Dandeno [Bot. Gazette 32, 229 (1901)] has recently called attention to a certain amount of confusion which has existed among both chemists and physiologists as to the preparation of a normal solution, and it has seemed wise to describe in detail the procedure followed in this investigation.

bright, white surface. If the seeds are germinated in a proper medium (sphagnum or peat moss saturated with water was actually employed) the root is usually straight or nearly so. These characteristics are important, as they permit the easy and accurate measurement which is essential to a determination of the amount of growth made during a given period. The white lupine has the further advantage of being a favorite subject for experiment with plant physiologists, so that numerous data for comparison are available.

In one series of experiments lupine plants were used which had been grown for eleven days in a prepared culture solution, and had not only developed a considerable root system, but had unfolded two or three leaves in addition to the seed leaves. In these plants all the processes essential to the life of a mature individual were undoubtedly in full activity. As a rule, however, a much earlier stage of growth was preferred, as clearly affording a more sensitive index of the effect of solutions. Experiments with older plants indicated that they are less delicate registers of toxic effect. An additional advantage in using very young plants is that they are practically independent of the substratum so far as food supply (that is, the mineral ash constituents) is concerned, that stored in the thick cotyledons answering all purposes. Consequently the confusion which would unavoidably arise if a culture solution of several salts containing the necessary elements of plant food were introduced is avoided by the employment of seedlings.

Lupine seedlings were transferred directly from the sphagnum, in which they had germinated twenty-four to forty-eight hours previously, to the solution in which the experiment was to be made. In this stage of growth the seed leaves are still closely appressed one to another, and are pale yellow in color. The initial root is 3 to 6 cm. long, and shows as yet no indication of the appearance of lateral branches. Care was taken to keep the moss so wet as to preclude a normal development of root hairs; and in this respect the result would be the same if the radicles had been immersed in water immediately after germination. It was desired to render as slight as possible the change of conditions in transferring from one medium to the other. There is every reason to believe that under these circumstances the amount of injury sustained by the plants as a result of the change of substratum was reduced to a minimum.[1]

[1] Wolf demonstrated [Landwirthsch. Versuchsst., 6, 203. (1864)] that plants which had been grown in soil until a considerable root system was developed and then shifted to an aqueous solution (as in the experiments of De Saussure and others) could not be depended upon to give as satisfactory results as plants which had been cultivated from the moment of germination in aqueous solutions. But in the case of seedlings transferred from loose wet sphagnum to water before any lateral roots had appeared no difficulty of this sort need be apprehended.

From the experiments of others with plants cultivated in salt solutions it would appear that *Lupinus albus* agrees pretty closely in point of sensitiveness with other large-seeded Leguminosæ, e. g., peas (*Pisum sativum*), beans (*Phaseolus vulgaris*), and, at least in some cases, with the horse bean (*Vicia faba*).[1]

In order to determine how closely plants of the same family correspond in their resistance to toxic effect, and at the same time to obtain data as to the behavior of a plant whose economic importance in arid regions is inestimable, a number of experiments were made with alfalfa (*Medicago sativa*). Here we have to deal with a plant whose seeds are many times smaller than those of the white lupine (1.5 to 3 mm. in greatest diameter). The radicle of the alfalfa seedling is correspondingly small and delicate, and hence requires more careful manipulation than does that of Lupinus. Alfalfa seeds were germinated in wet blotting paper, and were transferred to the solutions when the radicles were 1 to 2 cm. long.

A basis for comparison of the effects of toxic solutions upon plants of very different character and relationship is afforded by Heald's investigations of the action of extremely dilute solutions of hydrochloric acid upon seedling peas, pumpkins, and maize.[2] This author calculates that while one part of hydrogen ions (liberated by dissociation) in 6,400,000 parts of water killed the root tips of the pea (*Pisum sativum*),[3] one part in 3,200,000 was required to produce a similar effect upon the pumpkin (*Cucurbita pepo*) and one part in only 1,600,000 to destroy the root tips of maize (*Zea mays*). In other words, maize offers four times and the pumpkin twice as much resistance to the toxic effect of hydrochloric acid as do peas and lupines.

These results emphasize the importance of extending the present investigations to other plants of as widely different botanical relationship as possible. It is also of great moment that experiments be made with different stages of growth of the same plant, from the germinating seed to some point near maturity. It is as certain that the same kind of plant at various periods of development differs in its reaction to a given salt solution as that the reaction of the same plant to the same solution will be affected by variations of temperature and, perhaps, of illumination.[4]

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[1] But not always, for True [Annals of Botany, 9, 372, (1895)] found the white lupine "more strongly affected by a 0.25 per cent solution than is *Vicia faba* by one of 1 per cent $KNO_3$ content." He finds Pisum likewise more sensitive than *Vicia faba*.

[2] Bot. Gazette, 22, 136 (1898).

[3] The white lupine appears to be about equally sensitive to H-ions, for Kahlenberg and True [Bot. Gazette, 22, 91 (1896)] determined its limit of endurance in a solution of HCl to be $\frac{1}{64000}$ normal, while later Kahlenberg and Austin [Journ. Physical Chem., 4, 557 (1900)] fixed upon $\frac{1}{56000}$ normal as a more accurate limit.

[4] Storp [Landwirthsch-Versuchsst., 13, 76 (1884)] found zinc sulphate to be extremely injurious to germinating seedlings when exposed to the light, but harmless, or nearly so, in the dark.

The practical value of such a development of these studies is indicated by certain conditions to which agriculture in alkali regions is subject. It is well known that while at the beginning of the season the salt components are often pretty equally distributed through a considerable depth of soil and are in consequence comparatively harmless, the increased evaporation which accompanies increased temperatures and decreased atmospheric moisture as the season advances draws these salts to the surface of the soil, where they often effloresce and form "crusts" (especially in the case of sodium carbonate and sodium sulphate). Hence older plants are frequently exposed to the action of much more concentrated solutions than the same individuals when younger had to contend with. Furthermore, the accidents of irrigation may materially alter the alkali content of a soil in the midst of the growing season of a crop. It is therefore to be hoped that this important extension of the investigation may soon receive attention.

### DETAILS OF MANIPULATION.

The manner of preparing the solutions and the plants to be cultivated has already been described. A few words about methods and details followed in the experiments are in order.

To contain the solutions, glass vials nearly 3 cm. in diameter and holding about 70 c. c. of liquid were used. In the experiments with lupines, only one plant was suspended in each vial by means of a hole bored through a close-fitting thin cork stopper, the aperture being entirely closed by means of cotton batting. Protection against undue evaporation from the upper portion of the plant was secured by placing several vials in a glass jar containing a little water and inverting another jar over the whole. The plant was so adjusted in the cork that 1 to 3 cm. of the terminal portion of the radicle was immersed in the solution, the uppermost portion of the radicle extending through the vapor-saturated space between solution and stopper, while the hypocotylary section was invested with moist cotton.

In the case of alfalfa five or six plants were inserted in each vial in the following manner: A piece of aluminum wire was passed through the cork stopper in such a way as to allow it to be raised or lowered at discretion. On the portion of the wire included in the vial five or six small loops were made of proper size to hold in place each a seedling plant, with its seed leaves resting on the loop and its root immersed in the solution.

The duration of the culture in the salt solution was generally limited to twenty-four hours, as it was usually possible at the end of that period to determine accurately whether the root tip had been killed or not. Frequently, however, the plants were returned to the solution for a second period of equal duration in order to remove all doubt upon this point.[1] If at the end of that period no growth had taken

[1] In this particular, as in others, the experimental methods outlined by Kahlenberg and True [Bot. Gazette, 22, 87, 90 (1896)] have been followed, as it was desirable to make as close comparison as possible with their results.

place since the first examination, it was regarded as reasonably certain that the root tips had perished, and a less concentrated solution was tried. To obviate the possibility of mistaking a temporary condition of plasmolysis for final loss of vitality the roots were in earlier experiments transferred, after twenty-four hours, from the salt solution to distilled water; but this precaution soon proved to be needless. In all the experiments a control culture in distilled water was maintained under conditions of temperature and illumination identical with those of the salt cultures. As a matter of course, the growth of the roots is by no means as rapid in distilled water as in ordinary river water or in a prepared culture solution.

It was sought to keep the external conditions as nearly as possible uniform during the entire series of experiments and a temperature of 19° to 21° C. was maintained in the laboratory.[1]

The rate of growth during the period of experiment was ascertained by marking the radicle with india ink just before placing it in the solution. The mark, which was made as fine as was compatible with permanency, was placed at a distance of 15 mm. from the root tip in the case of the lupines and 10 mm. in the case of alfalfa (*Medicago*) so as safely to include the entire zone of active growth in the primary root.[2] This method of measuring the growth of roots was employed by Sachs in his classical studies upon the growth of primary and lateral roots,[3] and has been widely adopted by plant physiologists.[4] By comparison of the marked root with a ruled surface the amount of growth during any given period can be determined with all the accuracy necessary in experiments of the kind here described.[5]

By using a considerable number of individual plants in each experiment with each solution (usually five in case of Lupinus and ten or twelve in case of Medicago) it is believed that the variant due to individual differences in vigor has been practically eliminated.[6]

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[1] In this connection Klemm [Jahrb. f. wiss. Botanik, **28**, 659 (1895)] calls attention to the great variability exhibited by plants as to their limit of endurance in solutions of acids of definite concentration if other external conditions be varied. Askenasy [Ber. deutsch. bot. Gesellsch., **8**, 61 (1890)] describes the effect upon the growth of roots produced by different temperatures or by a variation of temperature during a limited period of time.

[2] Sachs determined the length of the growing portion, in the case of roots of other Leguminosæ, to be 8 to 10 mm. for *Vicia faba* and 3.5 to 6.5 mm. in *Pisum sativum*. [Arb. d. bot. Inst. Würzburg, 1, 413 to 419 (1873); Gesammelte Abhandl., **2**, 803 (1893)]

[3] Gesammelte Abhandl., **2**, 778.

[4] For example, Kahlenberg and True use this method in all their experiments with plants in solutions of toxic substances. [See Bot. Gazette, **22**, 88 (1896)]

[5] Askenasy [Ber. d. deutsch. bot. Gesellsch., **8**, 64, (1890)] shows that this method of marking causes a retardation of growth during the first hour thereafter, but that this is overcome after two hours. Consequently the method could be used without hesitation in these experiments, although it is sometimes attended by disadvantages when the phenomena of growth itself are studied.

[6] More than 2,500 seedlings of *Lupinus albus* and 700 of *Medicago sativa* were employed in the whole series of experiments.

Indeed, that this was the case was pretty effectually shown by several repetitions of the experiments with most of the solutions. It is also indicated by the general regularity with which toxic effect is shown to increase with every increase in concentration of the solution of each salt. By several times repeating experiments with solutions of approximately the critical strength the above-mentioned source of error due to fluctuations in temperature, etc., was likewise reduced to a minimum.

### DETERMINATION OF THE LIMIT OF ENDURANCE.

In ascertaining the degree of concentration of a given salt solution which will just permit the root tips to retain their vitality during the period of experiment, one must of course be able to determine also the point at which death definitely occurs. The death point is evidently to be sought far below the degree of concentration which permits no elongation whatever to occur during the period of experiment, for often radicles, of which the marked zone had increased in length several millimeters (even 6) at some time during the experiment, were indubitably dead at the end of twenty-four hours.[1] The mere fact of elongation, irrespective of the time in which it has taken place, does not therefore determine the concentration of a salt solution in which roots will survive, although sometimes useful in ascertaining whether the root is absolutely dead at the end of a given period. It is to the general condition of the apical portion of the root that we must look for a criterion. While it is sometimes difficult to describe those symptoms which denote the death of the root tip, it is comparatively easy to recognize them after one has acquired sufficient experience with the behavior of plants grown in toxic solutions.

One of the most easily detected of the phenomena accompanying death in plants is final loss of turgor due to excessive plasmolysis. In other words, the tissues lose their water, and are unable to make good the loss, even when restored to normal conditions. This is due primarily to a change in the osmotic equilibrium of the plant cells. Ordinarily, through the controlling activity of the protoplasm, a sufficient osmotic pressure is maintained in the sap cavity of the cell to

[1] Experiments were made with solutions of a strength known to be fatal, yet permitting some elongation during twenty-four hours. Sodium sulphate (0.05 normal), sodium carbonate (0.02 normal), and magnesium chloride (0.05 normal) were selected, and in every case it was found that elongation ceased entirely after three to five hours. In a water control, on the other hand, growth was still progressing at the end of six hours, and an examination at the end of twenty-four hours showed that it had been pretty equally distributed throughout the entire period. These results as to toxic action correspond with Sachs's statement [Landwirthsch. Versuchsst., 1, 219 (1859)]; Gesammelte Abhandl., 1, 430 (1892)] that "roots appear to lose more and more the power of absorbing water containing salt the longer they are in contact with it."

retain the necessary minimum of water. But through various influences, such as exposure of the tissues to a salt solution whose concentration exceeds a certain limit, this power of adjustment may be temporarily lost. In such cases a considerable proportion of the cell water diosmoses through the ectoplasm, and the protoplast in consequence shrinks away from the cell walls, to which it is normally closely applied. If the unfavorable condition persists, this temporary plasmolysis may become permanent, and the cell is killed outright.

Such disorganization due to extreme plasmolysis can usually be detected immediately by an examination of the plant tissues with the microscope, and is one of the best indications of death.[1] Roughly, however, injury of this nature is sufficiently indicated after a certain lapse of time by loss of rigidity and elasticity in the plant or part of a plant affected; in other words, it becomes flaccid. If, for example, a root thus rendered flaccid by culture in a salt solution fails to regain its turgor after being transferred to water or to a nutritive solution, it may safely be considered as injured beyond recovery. This was found to be the most satisfactory test of death employed.[2]

The color of the tissues is often a useful symptom of destructive changes. Thus all the sodium salts employed, when given in suffi-

[1] "The only externally perceptible change [indicating death] is in many cases collapse, a more or less strong, irregular recession of the protoplast from the cell wall, which does not, however, accompany by any means all reactions of substances which occasion death." [Klemm, Desorganisations-erscheinungen der Zelle. Jahrb. für wiss. Botanik, 28, p. 657 (1895).]

[2] Sachs [Arb. bot. Inst. Würzburg, 1, 386; Gesammelte Abhandl., 2, 774] mentions as an indication of the approaching death of the root tip the disorganization of the cells of the root cap, which becomes mucilaginous. This was noted in many cases, but was not found to be a practical test of complete loss of vitality. Another indication of injury to the apical portion of the root is a sharp bend near the tip, which is very different from the normal gentle curvatures. This usually appears where loss of turgor from plasmolysis is not manifested. While indicating injury, this symptom by no means necessarily implies complete loss of vitality and, therefore, does not serve our purpose as a symptom of death. Solutions of a certain concentration of magnesium sulphate, magnesium chloride, and calcium bicarbonate were found to produce this phenomenon in a marked degree. In the case of the salt last mentioned the roots continued to grow slowly in distilled water, during a second period of twenty-four hours. True [Ann. of Botany, 9, 377, (1895)] alludes to these "sharp curves characteristic of injury."

Another means of detecting loss of vitality in protoplasm, to which, however, recourse was not had in the progress of this work, is its coloration when dead by means of nigrosin, which does not color and does not injure living protoplasm. See Pfeffer [Ueber Aufnahme von Anilinfarben in lebende Zellen. Unters. aus d. bot. Inst. Tübingen, 2, 268, 269], who found in experiments with roots of duckweed (Lemna) and with Spirogyra that nigrosin is not absorbed by cells while alive. Living root hairs exposed for three days to a 0.5 per cent solution of this stain assumed no coloration whatever, while hairs after death when similarly treated readily absorbed it.

cient amount, decolorized the tissues of the apical portion of the root. This lost its normal brilliant white appearance[1] and assumed a lurid-whitish color. In the case of sodium carbonate ($Na_2CO_3$) and of sodium bicarbonate ($NaHCO_3$) there occurred a marked clearing of the tissues similar to that produced by the hydrates of potassium and sodium, the root tips becoming nearly transparent. This change is completed long before any loss of turgor is apparent. Magnesium salts (chloride and sulphate) discolored the surface of the roots, producing brownish spots which gradually spread over the whole surface.[2] The difference in character of physiological effect produced by salts of the same acid in the case of sodium on the one hand, and of magnesium on the other, is very great when gauged by these external appearances.

Another effect produced by some of these salts is an irregular enlargement of a portion of the root. This is very marked in the case of calcium chloride, in a solution of 0.3 normal or thereabouts. The root just above the tip develops a fusiform swelling of which the greatest transverse diameter (2 to 3 mm.) lies 5 to 10 mm. from the apex of the root. A less marked formation of this sort is sometimes produced by magnesium chloride, and even by other salts.[3]

It is well to emphasize once more the fact that the death of the tip of the primary root, and not that of the plant as a whole or even of the entire root, was taken in these experiments as the indicator of the toxic action of solutions. The condition of the distal 10 to 20 mm.

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[1] The "shining white opaque appearance which is characteristic of all healthy roots and which is due to air contained in the intercellular spaces." (Sachs, Landwirthsch. Versuchsst., 1, 216; Gesammelte Abhandl., 1, 427).

[2] Mettenius [quoted by Wolf in Landw. Versuchsst., 7, 202, (1865)] found that these spots, which appear on the roots of both the bean and maize when placed in solutions of magnesium salts, are due to a coagulation of the contents of the epidermal cells, which he did not, however, further describe. Wolf remarks that they do not appear upon plant roots in magnesium salt solutions if a salt of potassium, ammonium, or calcium be present.

[3] Sachs (Arb. bot. Inst. Würzburg, 1, 411, 412; Gesammelte Abhandl., 2, 800) describes swellings of apparently similar character which developed upon roots grown in moist air and watered at long intervals. Wolf [Landw. Versuchsst., 6, 218 (1864)] found that a concentrated solution of potassium sulphate acted in the same manner. "The root tips soon swell in the solution; the form of the root finally resembles that of the root of a tuber-bearing plant. Such swellings arise in particular abundance where lateral roots will break through." The action of a one-fourth per cent solution of potassium nitrate upon roots of *Lupinus albus* as described by True [Ann. of Botany, 9, 374 (1895)] is exactly similar to that of calcium chloride. "Swellings appeared near the tips and the ends tapered suddenly to sharp points. On the other hand, the growth in thickness was much greater than normal, the radicles above the swellings reaching the size of large radicles of *Vicia faba* of the same length."

only was necessarily involved.[1] In the more dilute solutions which are still considered toxic, because destroying the root tip, the proximal portion of the root and the upper part of the plant are often not conspicuously injured by twenty-four or forty-eight hours' exposure. After a certain lapse of time lateral roots are sometimes put forth and grow vigorously in a solution (especially of calcium chloride) which had killed the apical portion of the primary root.

This power of gradual accommodation on the part of the plant to a solution which at first checked its growth and even destroyed the sensitive tissues of the root tip has often been remarked. It is but a step from this to the well-known fact that by gradually increasing the strength of a salt solution in which plants are cultivated they can be made to endure a degree of concentration which would soon be fatal if administered directly.[2] It follows that the limits of endurance here recorded for *Lupinus albus* are merely those of its root tip, selected as being the most sensitive indicator, and are in some cases lower than the limits which would denote death of the plant as a whole. Furthermore, the limit of endurance for the entire plant could undoubtedly be still further elevated by gradually increasing the strength of solution in which the plants are cultivated.

But our present investigation aims merely at a comparison of the relative toxicity of the various "alkali" salts, to attain which the simplest and readiest means are to be preferred. A standard for further comparisons, rather than a thorough investigation of the problem in all its ramifications, is the end of the present paper.

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[1] This was likewise the objective of the experiments of Kahlenberg and True [Bot. Gazette, 22, 88, (1896)]. In order to obtain results closely comparable with theirs, especially as bearing upon the hypothesis of electrolytic dissociation, their mode of procedure has been closely followed in this as in other details. In advocacy of this method of determining toxic action, Professor True writes: "Repeated experiments for years have convinced me that the method used gives the most delicate and easily managed test that I know of for bulky objects like Lupinus roots."

Coupin [Rev. Gén. de Botanique, 10, 177 (1898)] criticises the work of Kahlenberg and True, previously quoted, to the effect that it is impossible to accurately determine the toxic limit of a solution in the short period of experiment (twenty-four hours) allowed by those authors. However, as Professor True observes, it was not the point at which the whole plant succumbs, but that which marks the death of the zone of growth in the primary root, which formed the objective of his experiments. Coupin's method was to grow his plants for several days in the solutions to be tested, taking the strongest solution in which the plant as a whole continued to grow after the first few hours as marking the limit of endurance ("équivalent toxique"). It is obvious, therefore, that no direct comparison is possible between the results obtained by Coupin on the one hand and by Kahlenberg and True, as well as those here recorded, on the other, Coupin's limits of endurance being necessarily much higher.

[2] Thus Stange [Bot. Zeitung, 50, 292 (1892)] found that root tips of *Lupinus albus* and *Phaseolus vulgaris* soon died if exposed directly to a 0.5 per cent solution of potassium nitrate, but by gradually increasing the concentration they could be made to endure nearly 1 per cent without death of the protoplasm.

## RESULTS WITH PURE SOLUTIONS.

### CONCENTRATION MAXIMUM PERMITTING SURVIVAL OF THE ROOTS.

By applying the methods and tests outlined above it was possible to determine with a reasonable degree of accuracy the limit of concentration for each of the salts in pure solution in which the root tips of young seedlings of white lupine could just survive. It is believed that, like conditions being maintained and the same plant in the same stage of development being used, the limits will not be materially altered by further experiment. Moreover, it is regarded as not improbable that the salts will be found toxic in about the order stated below if other plants or other stages of growth of the same plant be tested with them. The limit of endurance in a solution of each particular salt will doubtless be higher or lower for different objects, but the general sequence of harmfulness should remain practically unaltered, so far as the higher plants are concerned. Experience alone can demonstrate the correctness of this assumption.

The limit of concentration permitting roots of white lupine to retain their vitality during twenty-four hours is, for each of the more important readily soluble "alkali" salts, as follows, the limit being stated both in parts of salt per 100,000 of solution and in fractions of a normal solution:

TABLE I.—*Results of experiments with pure solutions.*

| Name of salt. | Degree of concentration. | |
|---|---|---|
| | Parts per 100,000 of solution. | Fractions of a normal solution. |
| Magnesium sulphate | 7 | 0.00125 |
| Magnesium chloride (1) | 12 | .0025 |
| Sodium carbonate | 26 | .005 |
| Sodium sulphate (2) | 53 | .0075 |
| Sodium chloride (3) | 116 | .02 |
| Sodium bicarbonate (4) | 167 | .02 |
| Calcium chloride | 1,377 | .25 |

NOTES.—(1) With magnesium chloride the limit of endurance (for the whole plant), as determined by Coupin [Rév. Gén. de Bot., 10, 188 (1898)], is 0.8 per cent, while with magnesium sulphate the limit is 1 per cent, thus reversing the order of toxicity for the two salts as given above. Wolfe (Landw. Versuchsst., 6, p. 214) notes the strongly toxic effect of magnesium solutions upon roots of bean and maize. The brown coloration of the surface of the radicle, induced by these salts, appeared a few hours after immersion. Wolf's suggestion that the very poisonous effect of magnesium sulphate may be due to the decomposition of the salt by excretions of the roots can not be regarded as possessing great probability. His experiments, which were designed primarily to ascertain the volume of water absorbed by the plant from solutions of various salts of different concentration, are considered by him to indicate that the cell wall [ectoplasm] is less permeable to sulphates than to other salts (l. c., p. 217). Loew (Bul. No. 18, Div. Veg. Phys. and Path., p. 42) found that Spirogyra died after four or five days of immersion in a 0.1 per cent solution of magnesium sulphate, but remained alive for a long period in equivalent solutions of sulphates of potassium, sodium, and calcium. Similarly a 1 per cent solution of magnesium nitrate killed a smaller Spirogyra in six to twelve hours, while the nitrates of potassium, sodium, and calcium, in solutions of corresponding strength, did not destroy the plant. The peculiarly poisonous action of salts of magnesium described by Loew is explained by him on the hypothesis that calcium forms intimate compounds with proteids, and that these are essential to the organization and life of the cell-nuclei and chloroplasts of the higher plants. Consequently, if magnesium is supplied without calcium to plants, especially in the form of readily soluble salts, such as chloride, nitrate, and sulphate, the acids of the magnesium salts would be attracted by the calcium which formed part of the nuclear proteid compounds. The latter would consequently be disorganized, magnesium being unable to take the place of calcium in proteid compounds without fatal disturbances of equilibrium in the cell. As evidence for this hypothesis is adduced the corrective effect of the addition of lime to either soils or culture solutions in which plants are suffering from magnesium poisoning, and the further fact that plants suffer less in culture solutions from which both calcium and magnesium are absent than in such as contain magnesium but no calcium. It must be observed, however, that the chemical rationale of this theory

rests upon the assumption that calcium is a stronger base than magnesium, and will exert a greater attractive force upon acids, while it ignores the application of the mass law to the distribution of an acid between two bases, which itself accounts very satisfactorily for the facts observed.

(2) Of sodium sulphate Wolf (Landw. Versuchsst., 6, pp. 210, 213) indicates that solutions of more than 0.05 per cent are toxic to roots of the bean (*Phaseolus vulgaris*). Loeb [Am. Journ. Physiology, 3, 398 (1900)], found sodium sulphate to be more poisonous than sodium chloride to eggs of a fish (*Fundulus heteroclitus*). This he attributes to a precipitation of calcium from its ion proteid compounds in the protoplasm, a reaction effected through the sulphions dissociated by sodium sulphate.

(3) The minimum toxic concentration for sodium chloride, the same plant and the same methods being used, is placed about three times as high (one-sixteenth normal) by True [Amer. Journ. Sci., ser. 4, 9, 187 (1901)]. As the experiments with sodium chloride here described were repeated several times, without variation in the result, no explanation for this discrepancy is apparent.

Many experiments have been made with sodium chloride as to its effects upon plants. It may be of interest to refer to some of those in which limits of endurance have been determined, especially as these are in all cases much higher than that given above for root tips of *Lupinus albus*. Storp [Biedermann's Centralbl., 13, 76 (1884)] found that sodium chloride in a solution of greater concentration than 0.01 per cent retarded the germination of seeds. Eschenhagen [Ueber den Einfluss von Lösungen verschiedener Concentrationen auf den Wachsthum der Schimmelpilze (1889)], quoted by Stange in Bot. Zeitung (1892, p. 255), gives the following limits for the active growth of fungi in solutions of sodium chloride and of sodium nitrate:

| Fungus. | Per cent sodium chloride. | Per cent sodium nitrate. |
|---|---|---|
| Aspergillus | 17 | 21 |
| Penicillium | 18 | 21 |
| Botrytis | 12 | 16 |

Richter [Ueber die Anpassung der Süsswasseralgen an Kochsalzlösungen Flora, 75, 4 (1892)] found that *Zygnema stellinum genuinum* lived two months in a 6 per cent solution of sodium chloride added to a culture solution, and more than a year when the sodium chloride solution was 2 per cent or weaker. De Freitag [Archiv für Hygiene, 11, 68 (1890)] is authority for the statement that *Bacillus tuberculosis* lived three months, and the typhus Bacillus six months in a saturated solution of sodium chloride. Coupin [Révue Gén. de Botanique, 10, 177 (1898)] obtained the following limits for various plants in solutions of sodium chloride:

| Plant. | Per cent limit of endurance. | Per cent in different solution. |
|---|---|---|
| Wheat | 1.8 | 0.5 |
| Peas | 1.2 | .25 |
| White lupine | 1.2 | ..... |
| Maize | 1.4 | ..... |
| Vetch | 1.1 | ..... |

According to W. Sigmund [Landw. Versuchsst., 47, 1 (1896)] the maximum concentration of NaCl solutions endurable by germinating seeds of cereals is 0.5 per cent, of legumes 0.3 per cent, of rape 0.1 per cent. Loew [Bul. 18, Div. Veg. Phys. and Path., p. 19] found that Spirogyra suffers in a solution containing 0.5 per cent of sodium chloride.

(4) Carbonic acid ($HCO_3$) is here regarded as a monovalent acid, so that a gram molecule (instead of one-half of a gram molecule) to the liter has been used in making up normal solutions of sodium bicarbonate. To prevent inversion to the normal carbonate ($Na_2CO_3$) [see Cameron and Briggs, Bul. 18, Div. of Soils, 1900; also Jour. Physical Chem., 5, 537 (1901)] solutions of the bicarbonate were always well charged with carbon dioxide and were tested for hydroxyl with phenolphthaleine before being used in culture experiments, and again at the end of the experiment. It is quite possible, of course, that a small error was thus introduced, as the carbonic acid formed by the dilution of carbon dioxide in water may have retarded somewhat the dissociation or ionization of the sodium hydrogen carbonate. It is improbable that sodium hydrogen carbonate, unaccompanied by the normal carbonate, would ever occur in nature except in the presence of an excess of carbon dioxide, which fact is a further justification of the procedure here described.

In order to demonstrate that this excess of carbon dioxide was not in itself injurious to the roots of white lupine, the following simple check experiment was made: Carbon dioxide was forced into distilled water until a saturated solution was obtained. Plants were then entered in this solution, which was protected as completely from loss of carbon dioxide as circumstances would permit. After twenty-four hours the solution was tested with barium hydrate, and the heaviness of the resulting precipitate of barium carbonate showed that very much more carbon dioxide still remained than is present in ordinary water. During this period the roots grew nearly as well as in water containing only the normal quantity of carbon dioxide. It might be supposed that a solution of carbon dioxide in water and presumably containing the hypothetical carbonic acid must needs be itself quite toxic, as it would be expected to yield the hydrogen ion which recent investigations have shown to be excessively toxic. In this connection some work of Pfeiffer [Ann. Chem. (2), 23, 625 (1884)] will prove interesting. This investigation showed that a solution of carbon dioxide is an exceedingly poor conductor; that in fact the highest conductivity observed in such solutions was only about a thousandth of that which Kohlrausch's work showed it should possess. See also Knox [Ann. Phys. Chem., 54, 44 (1895)] and Walker and Cormack [Journ. Chem. Soc., 77, 5 (1900)].

It would seem rational, therefore, to consider that carbonic acid does not exist itself, or at least in only minute quantities in solutions of carbon dioxide, but is *potentially* present in its constituents and only forms in the presence of some added influence, such as a base. And that, therefore, even a concentrated aqueous solution of carbon dioxide would contain no hydrogen ions, or so very small a quantity as to be ineffective against so delicate an indicator as a plant root.

Experiments to ascertain the limit of endurance in pure solutions were also made with seedlings of alfalfa (*Medicago sativa*). Although absolute limits for this plant have not, as yet, been determined, they appear to be somewhat lower for every salt than in the case of *Lupinus albus*, but more than one-half as high. Thus for magnesium sulphate the limit appears to lie between 0.000625 and 0.00125 normal, while for magnesium chloride the limit will be found between 0.00125 and 0.0025 normal.

A glance at the preceding table shows very clearly that it is the basic rather than the acid radicle of the salts used which chiefly determines their relative toxicity. In other words, the cathions derived from these salts are very much more active in their effect upon plant tissues than are the anions. This is strikingly brought out by a comparison among themselves of the three chlorides of magnesium, sodium, and calcium, on the one hand, and of the chlorides and sulphates of magnesium and sodium, respectively, on the other. In the former case, although the anions (Cl) are identical in kind we find magnesium chloride eight times as toxic as sodium chloride, and one hundred times as toxic as calcium chloride. In the latter case, magnesium sulphate is only twice as toxic as magnesium chloride, while sodium sulphate is little more than two and one-half times as injurious as the corresponding chloride.

The results with salts of magnesium, as compared with those of sodium, confirm the results obtained by W. Wolf, Loew, and others as to the strongly poisonous qualities of the former base.

All four of the salts of sodium with which experiments were made are widely distributed and often very abundant in the alkali regions of the western United States. As was to be expected, sodium carbonate or black alkali was found to be the most harmful of these, but it is not much more injurious than sodium sulphate. That the latter is much more poisonous than sodium chloride is a result not altogether anticipated at the beginning of the investigation.[1] As was predicted, sodium bicarbonate proved to be somewhat less toxic than sodium chloride.[2]

As a matter of fact, the limit of endurance in a solution of sodium bicarbonate is not much higher in parts of salt per 100,000 of water

[1] Stewart [Ninth Ann. Rep. Utah Agr. Exp. Sta. p. 26 (1898)] found sodium chloride more injurious than sodium sulphate to germinating seeds of legumes and cereals.

[2] Very different results from these here recorded as to the relative toxicity of the carbonate and bicarbonate of sodium were obtained by Coupin [Rév. Gén. de Botanique, 12, 180 (1900)]. Experimenting with seedlings of wheat, this author found that the least concentrated fatal solution ("équivalent toxique") is 1.1 grams per 100 of water for sodium carbonate, while for the bicarbonate it is 0.6 gram. Hence the latter would be twice instead of one-fourth as poisonous as the former. Sigmund [Landw. Versuchsst., 47, 2 (1896)] found that while $Na_2CO_3$ at a concentration of 0.5 per cent killed germinating seedlings of vetch and rape and retarded the development of wheat seedlings, $NaHCO_3$ at the same concentration was harmless.

and is no higher in fractions of the reacting weight than it is for sodium chloride. It should be mentioned, however, that the plants survive in a solution of the bicarbonate of the strength given in the table in much better condition than in the corresponding concentration of the chloride, so that the latter must be regarded as the more harmful of the two salts. The wide distribution of sodium bicarbonate and its abundance as a component of many alkali soils renders the demonstration of its marked poisonous effects upon vegetation, even when present in comparatively dilute solutions, a matter of no little importance. Although much less injurious than is the normal carbonate or "black alkali," the presence of this salt can not be neglected in future estimations of the value of western soils.

An explanation of the harmful action of sodium bicarbonate which at first suggested itself was that by its dissociation free hydrogen ions are liberated, though the weight of evidence on chemical grounds is rather against this view.[1] It has been shown by recent investigators[2] that it is probably the hydrogen ions dissociated by certain acids (especially the strong mineral acids) which make them so injurious to organisms, even in extremely dilute solutions. If this were the reason for the toxicity of sodium bicarbonate it would follow that water heavily charged with carbon dioxide, as in the check experiment described above (p. 20), would prove similarly injurious to plant roots by reason of the dissociation of hydrogen ions by the carbonic acid ($HCO_3$), which is supposed to be formed when carbon dioxide is dissolved in water. But, as has already been noted, no toxic effect was obtained with an aqueous solution of carbon dioxide.[3]

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[1] Walker and Cormack, Journ. Chem. Soc., 47, 5 (1900) and Bodländer, Zeit. für physik. Chem., 35, 25 (1900).

[2] Kahlenberg and True, Bot. Gazette, 22, 87 (1896); Heald, l. c., p. 134; Loeb, Pflüger's Archiv f. die gesammte Physiologie, 69, 4 to 9 (1898); Kahlenberg and Austin, Journ. of Physical Chem., 4, 553 (1900); True, Amer. Journ. Sci. ser. 4, 9, 183 (1900).

[3] There exists among plant physiologists some diversity of opinion as to the direct effect of large quantities of carbon dioxide upon the growth of roots. The subject is evidently one which needs a more thoroughgoing investigation, not only from a scientific standpoint, but from economic reasons also, as it is intimately connected with tillage and drainage problems. For an extended discussion of this question see Lopriore in Jahrb. für wiss. Botanik, 28, 531 (1895). The author mentions that Boehm found roots of the bean (*Phaseolus vulgaris*), when exposed to an excess of carbon dioxide, to be shorter, and the lateral roots fewer, than is ordinarily the case. Jentys [Bul. Internat. Acad. Sci. Cracovie, 1892, 306 (1893)], found that by passing atmospheric air to which had been added 4 to 12 per cent of carbon dioxide through the soil of culture pots, an injurious effect upon the roots of the bean and the yellow lupine could be detected, although the injury was less than in Boehm's experiments. On the other hand, wheat was practically unharmed. Lopriore (l. c., p. 623), concludes that carbon dioxide in excess has a hindering but not a permanently injurious influence upon the functions of protoplasm. This effect is not ascribable to the absence of oxygen, but is specific. Plant cells can gradually accommodate themselves to a quantity of carbon dioxide, which, if applied directly, would injure them. Lopriore's experiments were made chiefly with Mucor, yeast, and pollen grains and tubes.

As there is probably but a small difference in the amount of sodium ions yielded by sodium chloride and by sodium hydrogen carbonate, at the dilutions here involved, the difference in their toxicity observed must in all probability be ascribed mainly to the anions.

It is likely that the great toxicity of normal sodium carbonate is largely due to the hydroxyl ions resulting from the hydrolysis of this salt. In the case of the bicarbonate of sodium in all the experiments involving its use, and described in this paper, hydrolysis was avoided by dissolving carbon dioxide in the solution in amounts sufficient to prevent any inversion to the normal carbonate, a reaction which would necessarily result were hydrolysis of the bicarbonate permitted.[1] Since it seems reasonably certain that $HCO_3$ ions are not toxic, the toxic influence of the sodium bicarbonate solutions could be safely attributed to the sodium ion alone were it not for the fact that toxic solutions of this salt produce the peculiar "clearing" effect upon plant tissues which is well known in the case of the normal carbonate of sodium and of the hydrates of potassium and of sodium. This effect is very different from that caused by other salts of sodium, e. g., the sulphate and the chloride.

Calcium chloride was found to be ten times less injurious than is sodium chloride. For this reason, and because it rarely predominates in areas of any considerable size, this salt can not be regarded as, under ordinary circumstances, a dangerous component of alkali soils. As we shall presently see, there is reason to believe that it can in many cases be a highly beneficial component of the soil.

Attention should be directed to the fact that the figures given in the above table represent only approximate results, the determination of the absolute limit for each salt depending theoretically upon the testing of an almost infinite number of concentrations. Thus, as a rule, solutions of a concentration of 0.2, 0.15, 0.1, 0.075, 0.050, etc., normal were employed, although more numerous intermediate concentrations, e. g., of 0.2000, 0.1825, 0.1750, etc., normal could have been tested. However, it is doubtful whether the reaction upon plant tissues of finer differences could be detected, and it is believed that for all practical purposes a sufficient number of concentrations was used. As has already been noted, the limits of endurance in the case of different salts are not of precisely equal value, the roots not surviving in all in exactly the same condition. Thus roots which survived after twenty-four hours in a 0.005 normal solution of sodium carbonate presented a perfect appearance and grew vigorously in distilled water during a subsequent period of twenty-four hours. On the other hand, roots which endured a 0.25 normal solution of calcium chloride presented a markedly abnormal aspect at the end of twenty-four hours, and made little subsequent growth when transferred to water. Likewise

[1] See paper on Equilibrium between Normal Carbonates and Bicarbonates in Aqueous Solutions, Cameron and Briggs. Bul. 18, Div. Soils, U. S. Department of Agriculture (1901); Jour. Physical Chem., 5, 537 (1901).

roots survived in better condition in 0.0075 normal sodium sulphate than in 0.02 normal sodium chloride solution. It was found much easier to determine sharply the limit of endurance for sodium carbonate and sodium bicarbonate than for other salts, as in 0.005 and 0.02 normal solutions of the two carbonates, respectively, all, or nearly all, roots survived in apparently perfect condition, while in 0.0075 and 0.025 normal, respectively, all roots were killed and symptoms of advanced disorganization were apparent after twenty-four hours.

CONCENTRATION MINIMUM PROHIBITING ELONGATION OF ROOTS.

A comparison of the seven salts above enumerated in regard to the degree of concentration of each in which absolutely no elongation of the roots occurred during twenty-four hours is interesting, as illustrating how far this point is removed from that of the minimum concentration which is still toxic. It will be seen that the position of the salts in this scale does not at all correspond with their sequence in the table of limits of endurance. In many cases, especially when the solution was still more concentrated, not only no increase of length but a positive shrinkage of 0.5 to 2 mm.[1] was detected.

TABLE II.—*Concentrations which absolutely prevent growth.*

| Name of salt. | Concentration of solution. | |
|---|---|---|
| | Parts per 100,000 of solution. | Normal. |
| Sodium carbonate | 280 | 0.05 |
| Sodium bicarbonate | 417 | .05 |
| Magnesium chloride | 960 | .2 |
| Sodium chloride *a* | 1,160 | .2 |
| Sodium sulphate | 1,410 | .2 |
| Calcium chloride | 1,652 | .3 |
| Magnesium sulphate | 1,680 | .3 |

*a* According to Pfeffer (Pflanzenphysiologie, Ed. 2, 1, 414) a culture solution to which enough potassium nitrate or sodium chloride is added to render it isosmotic with a 2 per cent potassium nitrate or 1.7 per cent sodium chloride solution causes a cessation of growth in ordinary plants while an increase to 3 per cent is necessary to prevent growth in halophytes.

It is impossible to reconcile this sequence, as compared with that of Table I, with the notion, which still appears to find advocates, that the injurious effect of these salt solutions is merely a function of their osmotic pressures. If any fresh evidence were needed to disprove this assumption it is afforded by the fact, very clearly brought out in the present investigations, that marked toxic effects frequently appear long before loss of turgor has manifested itself or cessation of growth has occurred. It is certain that no useful conclusions as to the degree of toxicity of a solution can be drawn from its osmotic pressure.

True [Bot. Gazette, **26**, 407 (1898)] calls attention to the difficulty of distinguishing the purely chemical from the merely osmotic (plasmo-

[1] In some solutions this loss of length due to plasmolysis was as great as that found by Sachs in roots which were exposed for thirty minutes to the dry air of a room. (Arb. bot. Inst. Würzburg, 1, 396; Gesammelte Abhandl., 2, 784, 785.)

lyzing) effect of a salt solution. He experimented with Spirogyra in order to obtain means of making such distinction, comparing its behavior in a solution of cane sugar, which is believed to possess no chemically toxic properties, with that in solutions of sodium chloride and potassium nitrate. The maximum concentration of the sugar solution in which life could be maintained was determined to be 0.75 normal. Allowing for differences of dissociation, 0.46 normal should then be the maximum endurable concentration of a sodium chloride solution if only its osmotic pressure were involved. In fact, however, 0.1 normal was found to be the actual limit, so that a definite toxic action of sodium chloride must be admitted (loc., cit., p. 410).[1]

Were the injurious action of these solutions attributable to plasmolysis alone, an approximately equal amount of elongation should take place in solutions of different salts, if each solution contain an equal fraction of a gram equivalent to a given amount of water, granting that the dissociation of each salt was equally great at the given concentration, as would be approximately true for strong electrolytes at the concentrations here used; for elongation and growth in general are intimately connected with the turgor conditions of the tissues,[2] which, in turn, depend upon the osmotic force exerted by the surrounding solution. That force being equal for each of two solutions, the turgor and the amount of elongation of the roots immersed in each should also be equal if osmosis were the only factor involved. That this is not the case is sufficiently established by the figures given in Table II.

RESULTS WITH LESS SOLUBLE SALTS.

Besides the easily soluble alkali salts a few others were used in experiments, i. e., calcium sulphate [$CaSO_4$] calcium carbonate [$CaCO_3$], calcium bicarbonate [$Ca(HCO_3)_2$], and the carbonate and bicarbonate of magnesium [$MgCO_3$ and $Mg(HCO_3)_2$]. These were found to be either toxic in a very slight degree, indifferent, or positively stimulating to growth.

[1] From True's results it is clear that at the concentrations involved in our experiments with pure solutions the toxic effect observed must in every case be referred to action of a chemical rather than a purely physical nature. In some of the mixed solutions, such as the very concentrated ones containing calcium sulphate, it may be that their osmotic pressure determines the limit of endurance of the plant roots.

[2] For example that, except perhaps in rare instances, growth can not be resumed after an interruption (such as is occasioned by transference of plants from one medium to another) unless the turgor of the plant or the organ concerned is nearly or quite normal, was shown by Curtis [Bul. Torr. Bot. Club, 27, 1 (1900)] in the case of mycelia of Mucor, Botrytis, and Penicillium, grown in a plasmolyzing solution (4 per cent potassium nitrate). As this author expresses it, "there is a necessity of a certain turgor force before growth is possible, and growth can not occur until a turgor pressure has been reached which is normal to the plant growing in the given solution." (Loc. cit., p. 11.)

In a (necessarily dilute) solution of gypsum, which contained a considerable quantity of the undissolved salt in suspension, the plants grew decidedly more vigorously than in pure water.[1]

In a saturated, but necessarily very dilute, solution of normal calcium carbonate [$CaCO_3$], roots of Lupinus elongated nearly twice as much and remained in decidedly better condition during twenty-four hours than in distilled water. This solution gave a faint reaction for hydroxyl (with phenolphthaleine) at the beginning of the experiment, but none at the end of twenty-four hours, doubtless because of the production of carbonic acid through the excretion of carbon dioxide by the roots. But a solution of calcium bicarbonate [$Ca(HCO_3)_2$], made by saturating a portion of the same calcium carbonate solution with carbon dioxide, permitted only about one-third as much growth of the roots as took place in distilled water. Their condition was decidedly abnormal at the end of twenty-four hours, even the turgor being poor.[2]

Magnesium carbonate [$MgCO_3$], in a solution which gave a strong hydroxyl reaction with phenolphthaleine, allowed the roots to grow about as rapidly as in distilled water and to remain in about normal condition. On the other hand, a portion of the same solution to which an excess of carbon dioxide was added and in which no free hydroxyl could be detected (either before or after the experiment) exerted a strongly toxic action upon the roots. These made practically no growth during twenty-four hours; their turgor became decidedly inferior, and there occurred a marked discoloration of brownish spots, such as is produced by the readily soluble magnesium salts. Here it is obviously a case of a greater amount of magnesium in solution, owing to the presence of carbon dioxide in

[1] The stimulating effect which lime often exercises upon the growth of plants is too well known to require illustration. The presence of calcium salts in considerable quantity leads to a more vigorous production of root hairs than is normally the case, as can easily be demonstrated by culture experiments, in which only the tip of the root is immersed in the calcium salt solution. On the surface of the root above the solution a great number of unusually long root hairs appear. To this effect of the presence of lime, and the consequent readier absorption of potassium and ammonium salts from the soil, Loew attributes in part the benefits obtained by liming. (Bul. No. 18, Div. Veg. Phys. and Path., U. S. Department of Agriculture, p. 43.) That calcium salts directly stimulate growth, apart from the production of root hairs, is, however, shown by cultures with the root entirely immersed in an aqueous solution, thus precluding any important development of these organs.

[2] Schloesing's investigations [Comptes rendus, 74, 1552 (1872)] showed that 100,000 parts of pure water, i. e., free from dissolved carbon dioxide, would dissolve about 1.3 parts of calcium carbonate. Treadwell and Reuter [Zeit. für anorg. Chem., 35, 28 (1900)] showed that by increasing the pressure of the carbon dioxide in the gas phase in contact with the solution until it was one atmosphere, the solubility was increased so that 100,000 parts of water would dissolve 116 parts of calcium carbonate. Even at this extreme solubility there would be but 46 parts of calcium per 100,000 of water, as against about 60 parts in a saturated solution of calcium sulphate, in which plants thrive well.

excess.[1] Why the corresponding calcium solution should also hinder growth can not be satisfactorily explained at present.

### RESULTS WITH MIXED SOLUTIONS.

Upon comparing the limits of endurance for lupine roots in pure solutions of the "alkali" salts with the limits determined by the methods employed in a field survey, it became obvious that the former were vastly lower than the latter; and that furthermore the order of toxicity of the several salts as fixed by investigators in the field differed greatly from that obtained by experiments in the laboratory. This was strikingly the case with magnesium sulphate, which is decidedly the most toxic of the seven salts when alone in a pure aqueous solution, but which is regarded as the least injurious by students of alkali soils. But it was recalled that none of these salts usually occurs in any notable quantity in the soil save in the presence of one or several others, both of the readily soluble salts and of the comparatively insoluble magnesium carbonate, calcium carbonate, and calcium sulphate. The key to the discrepancy appeared therefore to lie in mixtures of the various salts, and the study of these became, logically, the next step in the investigation.

In experimenting with mixed solutions it was planned to test every possible combination of two of the readily soluble salts with which experiments were made in pure solutions. Another line of experiments, from which were obtained results which are believed to be of considerable scientific interest and from an economic point of view to indicate one of the possible solutions of the alkali soil problem, consisted in combining each of the readily soluble salts with each of three difficultly soluble ones—calcium sulphate, calcium carbonate, and magnesium carbonate. The only triple mixtures so far tried are those of each readily soluble salt (except calcium chloride) with calcium sulphate and calcium carbonate. Sodium bicarbonate was tested only in this triple mixture.

Although the work with mixtures of salts is by no means com-

[1] Treadwell and Reuter [Zeit. für anorg. Chem., 17, 199 (1898)] showed that at 15° C. and under a partial pressure of carbon dioxide in the vapor phase equal to zero, pure water dissolves about 63 parts of magnesium carbonate per 100,000. With a partial pressure of carbon dioxide in the vapor phase equal to one atmosphere there was dissolved about 1,211 parts magnesium hydrogen carbonate, equivalent to 698 parts of the normal carbonate per 100,000 of solution. It is thus seen that the solubility is enormously increased by the presence of carbon dioxide. Cameron and Briggs [Bul. 18, p. 22, Division of Soils, U. S. Department of Agriculture (1900)] showed that a solution of magnesium carbonate in solution in equilibrium with ordinary air contained about 18 parts of magnesium in 100,000 of solution, which might have been expected to be enough to prohibit growth in view of the toxicity of solutions of magnesium chloride and magnesium sulphate. It should be further noted that it was shown that 6 parts of the dissolved magnesium was combined as the normal carbonate, so that the solution contained more than appreciable amounts of OH ions, resulting from the hydrolysis of this latter salt.

pleted, the data thus far obtained throw so much light on the whole subject of alkali soils, and go so far to account for the fact that the limits of endurance of plants in pure solutions of the various salts are low as compared with those determined from the observations of survey parties in the field, that it seems advisable to present them here.

In the case of mixtures of two readily soluble salts, solutions of each, of twice the desired concentration, were mixed in equal volumes. Where one of the salts is a comparatively insoluble one, it was added in solid form to a solution of definite concentration of the soluble one, and the mixture was then diluted to the required concentration, as though the more soluble salt alone were present. (The source of error incurred by this method was considered so slight as to be practically negligible.) The mixture was then allowed to stand for a week or ten days with frequent shaking, in order to bring it to equilibrium before using. In all mixtures of magnesium carbonate and of calcium carbonate alone with other salts, the undissolved residue was removed by filtration. Likewise in earlier experiments with calcium sulphate added to other salts, the residue was removed, but in those upon which are based the limits given in the tables it was retained. In all cases where both calcium sulphate and calcium carbonate were added, the undissolved residue remained during the culture. The difference in limit due to the presence or absence of a solid excess was, however, usually imperceptible, and always slight.

In every case the object was to ascertain how far the limit of endurance for the roots in the presence of the more toxic salt could be raised by addition of one that is less injurious. Although the concentration of solution of the latter is invariably stated, if it be a readily soluble salt, it is the concentration of solution of the more poisonous salt as denoting a corresponding limit of endurance to which attention is chiefly directed. It is interesting that in cases where both of the salts mixed are readily soluble ones the less toxic salt appears usually to be more effective in neutralizing the more toxic one when added in concentration somewhat above rather than below that in which plant roots will endure it when alone. Thus, in a mixture containing equal volumes of 0.0075 normal sodium carbonate and 0.01 normal sodium sulphate, roots of two plants survived, but all died when the mixture contained 0.0075 normal sodium carbonate and only 0.005 normal sodium sulphate. Also a majority of the roots could retain their vitality in a mixture containing equal volumes of 0.0025 normal magnesium sulphate and of 0.01 normal sodium sulphate, but not in 0.0025 normal magnesium sulphate plus 0.005 normal sodium sulphate. Similar results were obtained by adding sodium sulphate to magnesium chloride and sodium chloride to magnesium sulphate. The reverse was true, however, in the mixtures of magnesium chloride and sodium chloride, the less concentrated solution of the latter proving more beneficial.

The concentrations are stated, as in preceding tables, both in parts of salt to 100,000 of solution and in fractions of a normal solution.

In the following tables of the effects of mixtures each of the more soluble alkali salts (excepting sodium bicarbonate) is taken up in succession in the order of its toxicity in pure solution. The neutralizing effect is expressed in terms of the greatest concentration of the more toxic salt endurable in the presence of the less toxic one. As the determination of the value of a less injurious salt in neutralizing a more toxic one was the objective of all experiments with mixtures, it follows that the number of added salts decreases successively from table to table. For comparison, the limit of endurance for the more toxic salt in pure solution is stated at the head of the table. The details of neutralizing effect upon each salt are taken up in connection with its respective table, while a discussion of the general significance of the whole series of experiments with mixtures of two solutions is appended.

The results embodied in Tables III to IX were obtained from experiments with *Lupinus albus* only. In Table X, however, the limits are given for both *Lupinus albus* and *Medicago sativa* (alfalfa) in solutions of each readily soluble salt (excepting calcium chloride) in the presence of an excess of calcium sulphate and calcium carbonate together.

### MAGNESIUM SULPHATE IN MIXTURES.

The following table shows the results of experiments with Lupinus in solutions of magnesium sulphate with other salts added:

TABLE III.—*Limits for magnesium sulphate in mixtures.*

| Name of salt added. | Greatest endurable concentration of magnesium sulphate. | | Concentration of the salts added. | |
|---|---|---|---|---|
| | In fractions of a normal solution. | In parts per 100,000 of solution. | In fractions of a normal solution. | In parts per 100,000 of solution. |
| None | 0.00125 | 7 | | |
| Magnesium chloride | .000625 | 3.5 | 0.0025 | 12 |
| Sodium carbonate | .00125 | 7 | .0025 | 13 |
| Sodium sulphate | .00375 | 21 | .01 | 80 |
| Sodium chloride | .0075 | 42 | .015 | 87 |
| Calcium chloride | .2 | 1,120 | .2 | 1,101 |
| Magnesium carbonate | .01 | 56 | Saturated. | Saturated. |
| Calcium carbonate | .02 | 112 | Saturated. | Saturated. |
| Calcium sulphate | .6 | 3,360 | Saturated. | Saturated. |
| Calcium sulphate and calcium carbonate | .4 | 2,240 | Saturated. | Saturated. |

In the light of figures given above, the enormous discrepancy between the results obtained by experiments with this salt in pure solution and the limit determined by field survey is completely obliterated. For in alkali lands magnesium sulphate is rarely, if ever, found in any quantity except in the presence of calcium sulphate; and it is commonly accompanied by both sodium and calcium sulphate (the Billings,

Mont., type of alkali soil[1]). Addition of sodium sulphate, which is itself so injurious in a pure solution, raises the limit for magnesium sulphate three times, while the presence of calcium sulphate allows a small proportion of the roots to barely survive during twenty-four hours in a solution of magnesium sulphate 480 times as concentrated as that which, in pure solution, represents the limit of endurance. A careful comparison was made between 0.3 and 0.4 normal solutions of magnesium sulphate, both in the absence and the presence of an excess of calcium sulphate, five individuals of *Lupinus albus* being cultivated for 48 hours in each of the four solutions. The following table gives the results:

TABLE IV.—*Magnesium sulphate with and without calcium sulphate.*

| Solutions. | Average elongation of the marked portion of the root. | General condition of the roots. |
|---|---|---|
| | *Millimeters.* | |
| Magnesium sulphate (0.3 normal) | 0.7 | Extremely flaccid, and discolored with brownish blotches; extremely plasmolyzed. |
| Magnesium sulphate (0.3 normal) + calcium sulphate. | 10.2 | Turgor normal; plasmolysis none; but all roots quite badly discolored. |
| Magnesium sulphate (0.4 normal) | .3 | About as in 0.3 normal. |
| Magnesium sulphate (0.4 normal) + calcium sulphate. | 13.0 | Turgor normal; plasmolysis none; all but one root quite badly discolored. |

In both pure solutions the protoplasm of the nearly isodiametric cells of the periblem was completely withdrawn from the cell wall and collected with the nucleus in a compact mass near the center of the cell; while in both solutions to which calcium sulphate had been added no trace of plasmolyzing action could be detected in the cells of the periblem, the protoplasm being closely applied to the wall, with large vacuoles in the older cells, and the nucleus usually peripheral. Precautions were taken while preparing the sections to keep the tissues immersed in the culture solution, and the absence of plasmolysis in the roots taken from the solutions containing calcium sulphate is sufficient evidence that the pure solutions had produced this effect during the period of culture rather than after withdrawal.[2]

[1] See Whitney and Means, Bul. 14, Div. Soils, U. S. Department of Agriculture (1898), and Cameron, Bul. 17, p. 32, Div. Soils, U. S. Department of Agriculture (1901).

[2] Wolf's observation (see footnote, p. 40) that both $Ca(NO_3)_2$ and $Mg(NO_3)_2$ are readily absorbed by plant roots when mixed together, while neither is readily absorbed from a pure solution, renders it highly probable that in this case of a mixture of $MgSO_4$ and $CaSO_4$ it is the rapid endosmosis of the salts into the cells of the plant roots which prevents plasmolysis of the latter. In short this mixture is to be compared with those substances described by Overton [Vierteljahrsschr. Naturf. Gessells ch. Zürich 40, 1 (1895)] which produce only transient plasmolysis, owing to their more or less rapid passage through the ectoplasm into the cell sap. As determined by De Vries [Jahrb. für wiss. Botanik, 14, 537 (1884)], a 1.8 per cent solution of magnesium sulphate (which would correspond to our 0.3 normal

In the presence of both calcium sulphate and calcium carbonate added in excess to a solution of magnesium sulphate, the limit of endurance is only two-thirds as high as when calcium sulphate alone is added.

Calcium as the chloride has also a powerful effect in neutralizing the toxicity of magnesium sulphate. But here the addition of a new anion (Cl), besides the added cathion (Ca), seems to diminish the beneficial effect of the latter, since the chloride, although a readily soluble salt, raises the limit for magnesium sulphate only one-third as much as does the little-soluble calcium sulphate. In a mixture of calcium chloride and magnesium sulphate a crystalline precipitate of calcium sulphate separates slowly or rapidly in proportion to the concentration of the solutions, so that the case becomes that of the contact of solid calcium sulphate with a solution of magnesium chloride. As would be expected, the limit of endurance for magnesium sulphate plus calcium chloride is the same as that for magnesium chloride plus calcium sulphate (Table V).

Sodium salts are very much less effective in neutralizing magnesium sulphate than are salts of calcium. In the case of sodium salts it is the chloride which is most effective, so that here we seem to have a beneficial effect of the anion as well as of the cathion. Yet the absence of any neutralizing effect when magnesium chloride is added to magnesium sulphate shows that the Cl ions alone are ineffective.

In one case the addition of a salt with a common basic ion—i. e., magnesium carbonate—raises the limit of endurance in magnesium sulphate eight times.[1] By a simple process of elimination, since magnesium ions are ineffective in the form of magnesium chloride when added to magnesium sulphate, although chlorine ions appear to have in themselves some neutralizing value when added as sodium chloride, we are compelled to attribute the beneficial influence of magnesium carbonate to $CO_3$, or more probably $HCO_3$, ions, a point to which we will return in discussing the stimulating effect of dilute solutions of sodium carbonate and sodium bicarbonate. Noteworthy is the fact that calcium carbonate, although much less soluble than the corresponding salt of magnesium, is twice as effective an antidote for magnesium sulphate. This affords another striking proof of the great efficacy of calcium as a remedy for magnesium poisoning.

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solution), is the isotonic equivalent of a 0.1 normal solution of potassium nitrate, which is usually taken as the unit in measurements of osmotic pressure of solutions. True [Bot. Gazette, 26, p. 410 (1896)] found that plasmolysis of Spirogyral cells in a $KNO_3$ solution first appeared at a concentration of 0.25 normal. De Vries' results seem to indicate that the osmotic value of each component in a mixed solution (of two or three salts) is equal to that of the respective component when present alone at the given concentration, a point not in accord with well-established facts.

[1] The roots barely survive in poor condition in a 0.01 normal magnesium sulphate solution plus an excess of magnesium carbonate; but in 0.005 normal magnesium sulphate solution plus magnesium carbonate some of the roots were perfectly normal after a twenty-four hours' culture.

MAGNESIUM CHLORIDE IN MIXTURES.

The results of experiments with magnesium chloride in mixtures with other salts are shown in the following table:

TABLE V.—*Limits for magnesium chloride in mixtures.*

| Name of salt added. | Greatest endurable concentration of magnesium chloride. | | Concentration of the salts added. | |
|---|---|---|---|---|
| | In fractions of a normal solution. | In parts per 100,000 of solution. | In fractions of a normal solution. | In parts per 100,000 of solution. |
| None | 0.0025 | 12 | | |
| Sodium carbonate | .0025 | 12 | 0.00675 | 19.5 |
| Sodium sulphate | .01 | 48 | .01 | 80 |
| Sodium chloride | .01 | 48 | .02 | 116 |
| Calcium chloride | .1 | 480 | .15 | 735 |
| Magnesium carbonate | .0025 | 12 | Saturated. | Saturated. |
| Calcium carbonate | .04 | 192 | Saturated. | Saturated. |
| Calcium sulphate | .2 | 960 | Saturated. | Saturated. |
| Calcium sulphate and calcium carbonate | .2 | 960 | Saturated. | Saturated. |

In the alkali soils of the Western United States magnesium chloride rarely occurs in such large quantities as to be regarded as more than secondary in importance.[1]

As in the case of magnesium sulphate, calcium is found to be much more effective than sodium in neutralizing magnesium, but here calcium chloride is relatively more effective than with magnesium sulphate, raising the limit for magnesium chloride one-half (instead of only one-third) as far as does calcium sulphate. But calcium is much less effective with the chloride than with the sulphate of magnesium, as is evident from the relative efficacy of calcium sulphate in raising the limits of endurance of the two magnesium salts. Hence we have here another indication (as in the case of calcium chloride added to magnesium sulphate) that chlorine ions by their presence lower the neutralizing efficacy of calcium; although in the absence of the latter base, magnesium chloride is only one-half as toxic as is magnesium sulphate. While the beneficial effect of calcium sulphate upon magnesium sulphate is decreased by the addition of an excess of calcium carbonate, the presence of the carbonate does not affect the value of calcium sulphate as an antidote to magnesium chloride.

While calcium carbonate is equally effective in raising the limits of the two soluble magnesium salts (sixteen times), magnesium carbonate, which raised the limit of magnesium sulphate eight times,

[1] Magnesium rarely makes its specific effects upon plant life felt in the "alkali" soils, owing to the omnipresence there of considerable calcium salts. In certain areas of the Eastern States, notably in the so-called "serpentine barrens" of Pennsylvania and Maryland, it appears to be relatively more important, probably because it is there present in excess over calcium, although the actual amount of both, which may be present in the soil solutions at any given time, must be extremely small.

has no effect upon magnesium chloride. As it appears to be necessary to regard the $HCO_3$ ions as the effective element in the former combination, we must conclude that these act beneficially in the presence of Mg and $SO_4$, but are powerless in the presence of Mg and Cl. But as calcium carbonate is equally effective as an antidote to magnesium chloride and to magnesium sulphate, it would follow that the power of Cl ions to hinder the effect of $HCO_3$ ions disappears in the presence of Ca ions, while, as already noted, Cl ions appear to diminish the value of Ca ions as an agency for counteracting Mg ions. Comparisons such as these show how difficult it is to attempt an interpretation of toxicological phenomena in the light of current chemical and physiological ideas. Possibly determinations of the solubility and degree of dissociation of these different salts in mixtures may afford some clue to the numerous anomalies. On the other hand, it is difficult to see any justification for using the reactions of organisms in determining the dissociation constants of electrolytes. The many nonconcordant results recently described in the literature can hardly be regarded as throwing discredit upon the dissociation hypothesis, but rather as demonstrating the unsatisfactory nature of the method employed for the investigation in hand.

Sodium sulphate and sodium chloride are equally effective in raising the limit of magnesium chloride (four times). The former is more effective, and the latter decidedly less so, than in the case of magnesium sulphate, so that the anions (Cl, $SO_4$) and not alone the cathions (Mg, Na) appear to make their influence felt in these cases.

### SODIUM CARBONATE IN MIXTURES.

Table VI shows results of experiments with mixtures of other salts with sodium carbonate:

TABLE VI.—*Limits for sodium carbonate in mixtures.*

| Name of salt added. | Greatest endurable concentration of sodium carbonate. | | Concentration of the salts added. | |
|---|---|---|---|---|
| | In fractions of a normal solution. | In parts per 100,000 solution. | In fractions of a normal solution. | In parts per 100,000 of solution. |
| None | 0.005 | 28 | ..... | ..... |
| Sodium sulphate | .0075 | 39 | 0.01 | 80 |
| Sodium chloride | .0025 | 13 | .01 | 58 |
| Calcium chloride | .25 | 1,300 | .25 | 1,377 |
| Magnesium carbonate | .01 | 52 | Saturated. | Saturated. |
| Calcium carbonate | .0075 | 39 | Saturated. | Saturated. |
| Calcium sulphate | .03 | 156 | Saturated. | Saturated. |
| Calcium sulphate and calcium carbonate | .03 | 156 | Saturated. | Saturated. |

As the above table shows, sodium chloride is ineffective as an antidote to sodium carbonate; calcium carbonate barely raises the limit

of endurance, while magnesium carbonate merely doubles it. It is interesting that magnesium carbonate should here be more effective than the corresponding salt of calcium, since in all other cases the latter is the more beneficial.[1] Sodium sulphate is likewise of very little neutralizing value, and the soluble salts of magnesium possess none so far as was ascertained. Calcium sulphate raises the limit only six times, the presence or absence of an excess of calcium carbonate not affecting the value of the sulphate. This comparatively slight efficacy of calcium sulphate in neutralizing "black alkali" is rather surprising in view of the accepted ideas of students of alkali soils in regard to the curative value of gypsum.[2] The comparative inefficacy of calcium sulphate in this case contrasts strikingly with its power to neutralize sodium in the forms of sulphate (Table VII) and chloride (Table VIII).

Calcium chloride is the only salt found to be very effective in neutralizing sodium carbonate, raising the limit of endurance for the latter fifty times. A mixture of solutions of the two salts causes an immediate heavy precipitate of calcium carbonate, to which fact the efficacy of the added salt must be largely ascribed. We should be dealing in this case with a solution of sodium chloride containing a large excess of calcium carbonate. Yet by direct addition of solid calcium carbonate to a solution of sodium chloride, the limit of endurance for the latter can be raised only three times, i. e., to 0.06 normal (see Table VIII). Here again chemistry appears to be powerless to afford an explanation of a phenomenon which, in the present state of our knowledge, must be regarded as paradoxical.[3]

A very noteworthy result was obtained by experiments with sodium carbonate, as well as with sodium bicarbonate, in the presence of an excess of calcium sulphate and calcium carbonate. In solutions of critical concentration of both of these mixtures a majority of the roots of the lupine plants were completely destroyed with pronounced

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[1] The probability of the formation of a double carbonate, with a consequent lowering of the active mass, as well as a probable change of nature of the ions, suggests itself very forcibly in this connection. It is hoped that time and opportunity will be found in the near future to test this supposition in the laboratory.

[2] Hilgard, Bul. 128, Agr. Exp. Sta., Univ. Calif., pp. 16 to 18 (1900). It should be stated, however, that Hilgard recommends the application of gypsum under physical conditions which would not probably be considered analogous to those under which the experiments here described were performed.

[3] In marked contrast with this anomalous case is that of the mixture of magnesium sulphate and calcium chloride, in which a precipitate of calcium sulphate is formed and which is therefore to be regarded as a solution of magnesium chloride containing a solid excess of calcium sulphate. Here the limit of endurance is the same as when solid calcium sulphate is added directly to a solution of magnesium chloride. The same thing is true of a mixture of sodium sulphate and calcium chloride in which the limit of endurance is the same as for sodium chloride plus calcium sulphate.

corrosion due presumably to the action of hydroxyl ions, while a smaller number survived in apparently perfect condition, and this occurred in repeated experiments. In critical solutions of other salts and mixtures of salts, however, there was rarely such sharp difference in appearance between roots which survived and those which died during twenty-four hours' culture; as a rule none of the roots were in normal condition at the end of the experiment. In other words, the difference of individual plants in their power to resist toxic action appears to be more pronounced in the case of the two carbonates of sodium than of other "alkali salts." This would indicate that the selection of plants for resistance to "black alkali" offers a simpler problem than where resistance to other components of alkali soils is to be sought.

### SODIUM SULPHATE IN MIXTURES.

Experiments with sodium sulphate in mixtures with other salts show the following results:

TABLE VII.—*Limits for sodium sulphate in mixtures.*

| Name of salt added. | Greatest endurable concentration of sodium sulphate. | | Concentration of the salts added. | |
|---|---|---|---|---|
| | In fractions of a normal solution. | In parts per 100,000 of solution. | In fractions of a normal solution. | In parts per 100,000 of solution. |
| None | 0.0075 | 53 | | |
| Sodium chloride | .00375 | 26.5 | 0.01 | 58 |
| Calcium chloride | .2 | 1,272 | .2 | 1,102 |
| Magnesium carbonate | .03 | 212 | Saturated. | Saturated. |
| Calcium carbonate | .04 | 281 | Saturated. | Saturated. |
| Calcium sulphate | .5 | 3,530 | Saturated. | Saturated. |
| Calcium sulphate and calcium carbonate [a] | .3 | 1,908 | Saturated. | Saturated. |

[a] See Bul. 17., p. 22 et seq., Division of Soils, U. S. Department of Agriculture, 1901.

Sodium sulphate is very abundant in "alkali" soils, often occurring in contact with each or several of the other salts. In the Billings, Mont., type, for example, it is accompanied by the sulphates of magnesium and calcium, while in the Fresno, Cal., type it is in contact with sodium carbonate.

Most effective for neutralizing this salt is calcium sulphate, which raises the limit more than sixty times when added alone. In the presence of an excess of calcium carbonate, however, calcium sulphate can increase the limit of endurance for sodium sulphate only about forty times. This is probably due to a forcing back of the dissociation and decrease of solubility of the calcium sulphate by the calcium carbonate, although, as Cameron and Seidell[1] have shown, either salt is rather soluble in dilute solutions of sodium sulphate.

[1] Solution Studies of Salts Occurring in Alkali Soils, Bul. 18, Division of Soils, U. S. Department of Agriculture.

As in the case of all the other salts except sodium carbonate, calcium chloride is less effective than calcium sulphate, raising the limit only twenty-seven times. In this case, as in the mixture of calcium chloride with magnesium sulphate, a crystalline precipitate of calcium sulphate is formed, so that it actually becomes a case of the contact of calcium sulphate with a solution of sodium chloride, and the same limit was obtained by a direct test of this latter mixture. Calcium carbonate is much less effective in neutralizing sodium sulphate than in counteracting the toxic action of magnesium salts.

Calcium sulphate is more effective as an antidote to sodium sulphate than to any other salt tried except magnesium sulphate. In both these cases the anion of the added salt is the same as that of the more toxic one; hence the cathions alone seem to operate. Possibly a double salt of sodium and calcium is formed in this mixture. Since calcium sulphate is much less efficacious in neutralizing the chlorides of magnesium and sodium than the corresponding sulphates, while it is generally more beneficial than is calcium chloride, it seems almost certain that the beneficial action of Ca ions is in some way hindered by the presence of Cl ions. That Cl ions are in themselves less toxic than are $SO_4$ ions would appear from the fact that the chlorides of magnesium and of sodium are less injurious in pure solution than are the corresponding sulphates.

### SODIUM CHLORIDE IN MIXTURES.

Experiments with sodium chloride in mixtures with other salts yielded the results shown in the following table:

TABLE VIII.—*Limits for sodium chloride in mixtures.*

| Name of salt added. | Greatest endurable concentration of sodium chloride. | | Concentration of the salts added. | |
|---|---|---|---|---|
| | In fractions of a normal solution. | In parts per 100,000 of solution. | In fractions of a normal solution. | In parts per 100,000 of solution. |
| None | 0.02 | 116 | | |
| Calcium chloride | .2 | 1,160 | 0.2 | 1,101 |
| Magnesium carbonate | .04 | 232 | Saturated. | Saturated. |
| Calcium carbonate | .06 | 348 | Saturated. | Saturated. |
| Calcium sulphate | .2 | 1,160 | Saturated. | Saturated. |
| Calcium sulphate and calcium carbonate | .2 | 1,160 | Saturated. | Saturated. |

Sodium chloride is probably the most widely distributed and generally abundant of the soluble components of alkali soils, occurring practically wherever the land is notably impregnated with these noxious salts.[1] As the above table shows, calcium sulphate and calcium chloride are equally effective in neutralizing the toxicity of sodium chloride, although in the case of sodium sulphate and the

[1] A notable exception is the Billings area in Montana.

soluble salts of magnesium, the former is decidedly more beneficial than the latter.

As in the case of magnesium chloride, the presence of calcium carbonate does not affect the neutralizing value of calcium sulphate, although decidedly diminishing it in the case of magnesium sulphate and sodium sulphate. It has been shown by Cameron and Seidell[1] that an excess of solid calcium carbonate has but a very slight effect on the solubility of calcium sulphate in sodium chloride solutions at the concentrations here involved. And from the general resemblance between the phenomena presented by calcium sulphate in contact with sodium chloride and magnesium chloride solutions, it is probable that calcium carbonate would have a like effect in the latter cases. It is to be regretted that laboratory investigations of the solubility of solid calcium carbonate and calcium sulphate in contact with solutions of soluble sulphates have not yet been made.

### CALCIUM CHLORIDE IN MIXTURES.

In the experiments with calcium chloride in mixtures with other salts the following results were obtained:

TABLE IX.—*Limits for calcium chloride in mixtures.*

| Name of salt added. | Greatest endurable concentration of calcium chloride. | | Concentration of the salts added. | |
|---|---|---|---|---|
| | In fractions of a normal solution. | In parts per 100,000 of solution. | In fractions of a normal solution. | In parts per 100,000 of solution. |
| None | 0.25 | 1,377 | | |
| Magnesium carbonate | .25 | 1,377 | Saturated. | Saturated. |
| Calcium carbonate | .25 | 1,377 | Saturated. | Saturated. |
| Calcium sulphate | a0.3 | 1,652 | Saturated. | Saturated. |

a About.

Calcium chloride is quite generally distributed in alkali soils, being usually present in small patches wherever sodium chloride is abundant. As would be expected from the relatively very high concentration of the pure solution of this salt endured by roots of the white lupine, the limit can not be materially raised by the addition of other salts.

### SODIUM BICARBONATE IN MIXTURES.

Sodium bicarbonate was tested in mixture only with calcium sulphate and calcium carbonate together, which raised its limit of endurance two and one-half times (see Table X). It usually occurs in nature in contact with the normal sodium carbonate.

### CALCIUM SULPHATE AND CALCIUM CARBONATE IN MIXTURES.

In the tables of limits of endurance in mixtures, as in those of pure solutions, the figures do not perfectly state the case. For example,

[1] Bul. 18, Division of Soils, U. S. Department of Agriculture (1901).

although the limit of endurance in sodium carbonate plus magnesium carbonate is 0.01 normal, while for sodium sulphate plus magnesium carbonate it is 0.03 normal, the proportion of individual seedlings whose roots survive in good condition is decidedly greater in the latter mixture than in the former.

None of the readily soluble salts occurs abundantly in alkali soils save in the presence of calcium sulphate or calcium carbonate, and most often in contact with both. Hence it follows that the limits of endurance for the more soluble salts in the presence of these two salts of calcium, as obtained by means of water-culture experiments, should agree closely with the limits determined by soil investigators. This proved to be the case, due allowance being made for the influence of the physical properties of a soil as compared with an aqueous solution.

The following table serves to bring together, for ready comparison, the limit of endurance for roots of both white lupine and alfalfa in solutions of six of the easily soluble salts to which a solid excess of both calcium sulphate and calcium carbonate was added, the mixtures being brought to equilibrium before using.

TABLE X.—*Results with mixtures containing two calcium salts.*

| Name of salt. | Limits for lupine (Lupinus albus). | | Limits for alfalfa (Medicago sativa).[a] | |
|---|---|---|---|---|
| | Parts per 100,000 of solution. | Normal solution. | Parts per 100,000 of solution. | Normal solution. |
| Magnesium sulphate | 2,240 | 0.4 | 1,960 | 0.35 |
| Magnesium chloride | 960 | .2 | 960 | .2 |
| Sodium carbonate | 156 | .03 | 104 | .02 |
| Sodium sulphate | 2,160 | .3 | 2,160 | .3 |
| Sodium chloride | 1,160 | .2 | 1,160 | .2 |
| Sodium bicarbonate | 417 | .05 | 667 | .08 |

[a] In the case of alfalfa a few roots barely survive in 0.75 and in 0.3 normal magnesium sulphate, while in 0.25 normal they make a noteworthy amount of growth during forty-eight hours. In 0.2 normal sodium sulphate they make a decidedly better growth, and in 0.1 normal sodium chloride two and one-half times as much growth as in the water control.

The close correspondence between the white lupine and alfalfa in their resistance to the effects of these mixed solutions is worthy of note, especially as alfalfa appears to be more sensitive than the lupine to pure solutions. The only serious discrepancy occurs in the mixture of sodium bicarbonate, calcium sulphate, and calcium carbonate, to which alfalfa roots appear to be nearly twice as resistant as are those of white lupine.

That in the neutralizing effect upon more toxic salts which these two relatively insoluble salts exert calcium sulphate plays a much more important part than does calcium carbonate is obvious from a comparison of the limits of endurance in solutions to which either calcium sulphate or calcium carbonate alone has been added. Indeed, in the case of magnesium sulphate and of sodium sulphate the limit of endurance is decidedly lower in the presence of both calcium salts

than when calcium sulphate alone is added. On the other hand, the presence or absence of calcium carbonate appears to have no effect upon the neutralizing value of calcium sulphate when added to magnesium chloride, sodium chloride, or sodium carbonate.

An interesting comparison is that of the soluble salts, one with another, in respect to their degree of toxicity in pure solution on the one hand, and in the presence of an excess of calcium sulphate and calcium carbonate on the other. It will be observed that the sequence in the first column is very different from that in the second. The most toxic salt or mixture is placed at the head of each column.

TABLE XI.—*Order of toxicity with and without calcium salts.*

| In pure solution: | In presence of an excess of $CaSO_4$ and $CaCO_3$: *a* |
|---|---|
| Magnesium sulphate. | Sodium carbonate. |
| Magnesium chloride. | Sodium bicarbonate. |
| Sodium carbonate. | Magnesium chloride. *b* |
| Sodium sulphate. | Sodium chloride *b* |
| Sodium chloride. | Calcium chloride. |
| Sodium bicarbonate. | Sodium sulphate. |
| Calcium chloride. | Magnesium sulphate. |

*a* It has already been suggested that the limit in some of these highly concentrated solutions containing an excess of calcium salts may bear some relation to the osmotic pressure of the solution. It is therefore not a mere coincidence, perhaps, that the sequence in this column is almost identical with that in Table II (of concentrations precluding any growth during the culture).

*b* These two salts are equally toxic in mixtures if reacting weights be compared, while magnesium chloride is the more toxic of the two in parts of salt per 100,000 of solution.

The interest and importance of the results obtained from the experiments made with mixed solutions show the great desirability of extending further this line of investigation. In fact, no aspect of the work promises more substantial returns. An interesting problem among the many which suggest themselves in this connection is that of a possible relation between the degree of toxicity of a salt, alone or in mixture, and the readiness with which it is taken up by the plant from a solution. The occasion seems opportune to redirect attention to a series of experiments made long ago by Wilhelm Wolf[1] as to the

[1] Landw. Versuchsst., 7, 193 (1865). The studies were made with a series of solutions, each of which contained two salts in equal amount. Combinations were made with (1) salts of the same acid, but of different bases; (2) salts of the same base, but of different acids; (3) with both base and acid different. In each culture 200 c. c. of solution was employed, and after one-half of this volume had been absorbed by the plant (allowance being made for the small quantity of water evaporated directly from the solution) the amount of each salt taken up with the water was estimated by analysis of the residual 100 c. c. of solution. Young beans and maize were used in the experiments. Some of the results obtained were as follows:

From three mixtures, each containing 0.05 grams of each two salts, the plants absorbed in percentages of the original quantity of each salt supplied:

From ammonium nitrate plus calcium nitrate, 92 per cent of the former and 94 per cent of the latter.

From ammonium nitrate plus magnesium nitrate, 92 per cent of the former and 86 per cent of the latter.

From magnesium nitrate plus calcium nitrate, 74 per cent of each.

Potassium nitrate was taken up from all combinations with other nitrates

amount of each salt absorbed by a plant from a mixed solution. Especially interesting, as compared with the toxicological phenomena of pure and mixed solutions, respectively, are Wolf's results as to the effect of calcium sulphate in stimulating the absorption of other sulphates.

GENERAL SIGNIFICANCE OF RESULTS WITH MIXED SOLUTIONS.

To enter into a discussion, from the purely chemical point of view, of the widely accepted hypothesis of the dissociation of electrolytes in solution would be to exceed the proper limits of this paper.[1] It is sufficient to say that salts such as those with which we are here dealing are held to dissociate in dilute solutions, more or less com-

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(Na, $NH_4$, Mg, Ca) in absolutely greater amount than from a simple solution. From a solution containing 0.025 gram each of potassium nitrate and calcium nitrate the plants absorbed 100 per cent of the former and 88 per cent of the latter. From an equivalent solution of potassium nitrate plus magnesium nitrate, 100 per cent of the former and 88 per cent of the latter. The stimulation of the plant by the presence of calcium to take up greater quantities of potash is referred by Loew (l. c., p. 44) to the increased development of root hairs induced by the calcium. But if the presence of magnesium has exactly the same effect, as would appear from the experiment just quoted, we must look further for an explanation. Absorption of ammonium nitrate is decreased by the presence of other nitrates, *while that of calcium and of magnesium nitrates is stimulated thereby. It is remarkable that while neither of these last two salts is readily absorbed from a simple solution, both are easily absorbed when mixed together.*

Plants could be grown in mixtures of potassium and calcium sulphate ($K_2SO_4 + CaSO_4$) and of calcium and magnesium sulphate ($CaSO_4 + MgSO_4$), but never in mixtures of sulphates of potassium and sodium ($K_2SO_4 + Na_2SO_4$), of potassium and ammonium ($K_2SO_4 + (NH_4)_2SO_4$), nor of potassium and magnesium $K_2SO_4 + MgSO_4$), even when the solutions were very dilute.

Potassium and ammonium salts were taken up much more readily in the presence of a calcium salt than from a pure solution. This was notably the case with the sulphates, which are absorbed with difficulty from unmixed solutions. Gypsum (calcium sulphate) is absorbed in very small quantity in the presence of a potassium salt, but greatly stimulates absorption of the latter. From a mixture of calcium and magnesium sulphate little of either salt is taken up, but the presence of magnesium nitrate considerably increases the amount of calcium sulphate drawn from a solution.

From mixtures of a sulphate and a phosphate, the latter is always taken up in greater quantity. Magnesium sulphate is taken up in greater quantity in the presence of a phosphate than are other sulphates.

De Saussure's principle of the absorption of salts in solution by plant roots—i. e., that the salt is taken up in smaller proportion to the water absorbed than it occurs in the culture solution; in other words, that the residual solution becomes more concentrated—applies to the absorption of sodium chloride in the presence of a nitrate ($KNO_3$, $NH_4NO_3$, $Ca(NO_3)_2$), but does not hold as to the absorption of the nitrate itself.

[1] For the presentation of the subject in simple terms the reader is referred to a former publication by one of us. (Rep. No. 64, U. S. Department of Agriculture, p. 144, 1900.)

pletely at a given concentration according to the specific properties of the particular salt. The result is a liberation of ions—atoms or atomic groups carrying or in some way associated with an electric charge. Cathions, those furnished by the basic radicle, carry positive electricity, while anions, derived from the acid radicle of the salt, are negatively charged. Ions possess a much greater velocity[1] than do undissociated molecules, and it is now believed by many physiologists that salts owe to the properties of their ions rather than to their entire molecules the toxic and other action which they exert upon organisms.[2]

It is believed that the results of the present investigation tend to confirm this view, although it must be admitted that serious anomalies exist, to some of which attention has already been directed.

Pure solutions of the salts dealt with are shown to be generally injurious to plants, and this largely by virtue of the cathions which they yield, as a comparison of the position of the several salts in the table of toxicity in pure solutions shows conclusively. Thus magnesium salts, irrespective of the character of their anions, are much more injurious than is any sodium salt, while the three chlorides (of magnesium, sodium, and calcium) differ enormously in toxicity, regardless of the fact that they yield a common anion.

An inspection of the tables of limits in mixed solution given above makes it clear that the addition of a second, less toxic salt in most cases increases the concentration of solution of the more harmful one in which root tips can retain their vitality. It is also demonstrated that addition of a second salt of the same base, hence furnishing a different kind of anion only, is usually much less efficacious in raising the limit than is the admixture of a salt of a different base. Thus magnesium chloride is ineffective as an antidote to magnesium sulphate, sodium chloride to sodium carbonate or to sodium sulphate, and calcium carbonate to calcium chloride.

If the assumption be granted that in the dilutions here involved the magnesium salts are practically completely dissociated and that the anions do not have a toxic effect, then a 0.00125 normal solution of magnesium will be the limit when the metal is combined as the sulphate and a 0.0025 normal solution when combined as the chloride, but about a 0.002 normal solution when both chloride and sulphate are present, with two equivalents of the former to one of the latter. The same line of reasoning holds for the other cases cited, and from these facts it is evident that the anions have a part in determining the toxic effect of a

[1] That the physiological action of ions may be in some sort a function of their specific velocities is indicated by Loeb's comparison of the effects of hydrogen and hydroxyl ions, as well as of various basic cathions, upon the absorption of water by a muscle. [Pflüger's Archiv.. 69, 21, (1898).]

[2] Of a rapidly growing literature on this subject the papers of Kahlenberg and True and of Kahlenberg and Austin, dealing with plants, and those of Loeb, Garrey, Anne Moore, Kahlenberg, Clark and others, treating ion action upon animals, may be cited as of great importance. (See the Bibliography, p. 56.)

salt, although a much smaller one in general than have the cathions. Furthermore, these views are in harmony with Loeb's idea that $SO_4$ ions are more toxic than Cl ions, because they tend to precipitate calcium from its proteid compounds.

In other cases, however, addition of a salt which furnishes new anions, but not new cathions, to the mixture is effective in raising the endurable limit of concentration for the more toxic salt. A striking case is the elevation of the limit for magnesium sulphate eight times by the addition of magnesium carbonate. Here it would appear that the $HCO_3$ anions alone can be the effective agency. Sodium sulphate slightly raises the limit of sodium carbonate, and a relatively unimportant increase of the concentration of a calcium chloride solution in which lupine roots can survive is obtained by addition of calcium sulphate. But in these last two cases the effect is so small as to be almost negligible, and is perhaps entirely attributable to the forcing back of the dissociation of the more toxic salt rather than to any direct physiological action of the new anions.

The superior efficacy of cathions over anions in neutralizing the toxic effect of other cathions is illustrated by the discovery that sodium is equally effective as an antidote to magnesium chloride, whether it be added as sulphate ($Na_2SO_4$) or as chloride (NaCl).[1] A much more striking illustration is afforded by the fact that calcium, when added to a solution of magnesium sulphate or of sodium sulphate, is very much more efficacious when furnished as the relatively insoluble sulphate than as the readily soluble chloride. In other words, the presence of chlorine anions actually hinders the full exertion of the physiological effect of calcium cathions, unless we are to believe that the superior efficacy of calcium sulphate is due merely to its greater influence in retarding the dissociation of the sulphates of magnesium and of sodium.

If we turn now to the effect of mixtures in which two kinds of cathions are present we find that these are almost invariably much less poisonous than is the pure solution of the more toxic salt. Even the addition of a sodium salt (sulphate or chloride) to one of magnesium (sulphate or chloride) raises the limit of endurance for the latter three to six times. Still more remarkable is the effect of magnesium carbonate as an antidote to salts of sodium (carbonate, sulphate, chloride), raising their limits two to four times. But these effects are trivial as compared with the extraordinary efficacy of calcium in counteracting the toxic effects of other bases (magnesium, sodium).

Even when added as the but slightly soluble carbonate, calcium raises the limit of magnesium sulphate and of magnesium chloride sixteen times, of sodium sulphate more than five times, and of sodium

[1] On the other hand, sodium chloride is twice as effective as sodium sulphate in neutralizing magnesium sulphate.

chloride three times. Calcium chloride[1] mixed with an equal volume of a magnesium or a sodium salt raises the limit of the latter as follows: Magnesium sulphate, one hundred and sixty times; magnesium chloride, forty times; sodium carbonate, fifty times;[2] sodium sulphate, twenty-seven times, and sodium chloride, ten times.

The most effective of the calcium salts tried was, however, calcium sulphate. This, when added alone in solid excess, increases the maxima of concentration endurable by the roots as follows: Magnesium sulphate, four hundred and eighty times; magnesium chloride, eighty times; sodium carbonate, six times; sodium sulphate, sixty-six times, and sodium chloride, ten times. Here we have probably the greatest effect of one kind of ion in neutralizing the effect of another kind that has yet been obtained in experiments with plants.

It is noteworthy that the effect of the calcium ions upon different salts having a common basic ion differs greatly. Thus plant roots can endure three times the concentration of a solution containing magnesium cathions and sulph-anions to which calcium sulphate is added than they can of a solution containing magnesium cathions and chlor-anions plus calcium sulphate. Yet the former solution in the absence of calcium salts is endurable in concentration only one-half as great as is the latter without a calcium salt. Here the effect may be partly due to differences of dissociation in the two solutions. But it appears necessary to attribute the greater part of it to an adverse influence, presumably exerted by chlorine ions, upon the physiological action of calcium ions in the presence of magnesium ions. Similar problems are suggested by the wide differences in the degree to which calcium sulphate can neutralize the toxic action of each of the three sodium salts.

That the phenomena exhibited by the roots of plants in their reaction to these various mixed salt solutions are not to be regarded as mere functions of chemical changes in the solution itself is patent. The problem is undoubtedly a much more intricate one, involving chemical reactions of great complexity in the protoplasm of the plant itself. In this connection it is important to call attention to the strikingly similar results obtained by Loeb[3] as to the relative toxic effect upon animals of pure and of mixed solutions.

A pure salt solution, e. g., of sodium chloride, was found to be

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[1] Loew (Bul. No. 18, Div. Veg. Phys. and Path., U. S. Department of Agriculture, p. 33), referring to an experiment made by Boehm, appears to doubt the value of calcium in the form of the chloride as a plant nutrient, owing to the formation of hydrochloric acid in the assimilation of calcium by the plant. Here is another suggestion as to the reason for the inferiority of calcium chloride to calcium sulphate in neutralizing the toxic action of salts of other bases.

[2] As has already been noted (under Table VI), a heavy precipitate of calcium carbonate is formed in this mixture, so that it becomes in great part a solution of sodium chloride plus a solid excess of calcium carbonate.

[3] See the papers by this author cited in the Bibliography (p. 58).

strongly poisonous to marine animals in various stages of development—i. e., a fish (*Fundulus heteroclitus*), a jellyfish (Gonionemus sp.), and a sea urchin (Arbacia sp.). But the addition in small quantity of a salt yielding another kind of cathion, such as magnesium, potassium, and calcium, more or less neutralized this toxic effect, although each of these salts was itself toxic in pure solution. As in the case of plants, calcium was particularly effective. That it is the cathions rather than the anions added to the solution which are chiefly effective as counter agents is evident from the fact that of each base the chloride only was used. Moreover, in only one mixture of three chlorides could fertilized eggs of the sea urchin be brought to an advanced stage of development, but sodium bromide could be successfully substituted for sodium chloride in the mixture.[1] It is clear, therefore, that the anions play a very subordinate part in the physiological action of such mixtures.

Loeb suggests that the physiological effect of a pure solution, whether toxic or stimulating, is attributable to a reaction whereby various cathions which are assumed to enter into combination with the proteids of the organism are replaced by the cathion of the surrounding solution, in accordance with the law of mass. Thus, in case of an animal or organ immersed in a solution of sodium chloride, ions of calcium and of potassium would be forced from their organic compounds and sodium ions would be substituted for them. This would cause a disturbance of equilibrium and finally a cessation of irritability in the tissues. Such effect can be prevented, or, if it has not proceeded to the point of disorganization, counteracted by the addition to the solution of salts containing the corresponding cathions, i. e., potassium and calcium. Hence the author derives his conception of a "physiologically balanced salt solution," examples of which are sea water, the blood of animals, and a mixture of definite concentrations of the chlorides of potassium, sodium, and calcium. The chief function of such a solution is regarded as the maintenance of "a certain physical condition, a certain labile equilibrium, of the protoplasm or the colloids."[2]

From considerations such as these, and from the discovery that a close analogy as to absorption of water exists between the behavior of a frog's gastrocnemius immersed in a solution of a potassium, sodium, or calcium salt and that of potassium, sodium, and calcium soaps,[3] the development of Loeb's theory of the existence and function of "ion-proteid compounds" was logically inevitable. The hypothesis is stated as follows: "Salts or electrolytes in general do not exist in living tissues as such exclusively, but are partly in combination with

[1] Amer. Journ. Physiology, 3, 442 (1900).

[2] Ibid., 3, 445 (1900).

[3] See Pflüger's Archiv, 75, 303 (1899).

proteids. The salt or electrolyte molecules do not enter into this combination as a whole, but through their ions. The great importance of these ion-proteid compounds lies in the fact that by the substitution of one ion for another the physical properties of the proteid compounds change. We thus possess in these ion-proteid compounds essential constituents of living matter which can be modified at desire, and hence enable us to vary and control the life phenomena themselves. * * * If it be true that life phenomena depend upon the presence of a number of various metal proteids (Na, Ca, K, and Mg) in definite proportions, it follows that *solutions which contain only one class of metal ions must act as a poison.* The reason for this is that the one class of metal ions will gradually take the place of the other metal ions in the ion-proteids of the tissues. Even a pure NaCl solution must thus be poisonous, although this salt permeates all our tissues and is the main constituent of the [soluble] inorganic matter of the ocean."[1]

Pauli,[2] who published the same hypothesis almost simultaneously, states his views with greater positiveness. "The general distribution of the ion-proteid compound in the living organism can not be doubted; indeed, we have strong reasons for the assumption that all the proteids of the protoplasm exist there only in combination with ions." And again, "Not salts, but salt-ions, are indispensable to the organism."[3]

Loeb's experiments show that to the same ions or mixtures of ions different animals or different organs or stages of development of the same animal may react in a different manner. This was noted in the case of embryonic as compared with fully developed tissue and with myogenic as compared with nuerogenic contractions. Thus in pure solution magnesium chloride is more favorable to the development of fertilized eggs of the sea urchin than is sodium chloride, although the latter causes while the former prevents rhythmical muscular contraction. On the other hand, as the predominant salt in a triple mixture of chlorides (potassium and calcium being present in much smaller quantity), sodium chloride favors, while magnesium chloride prevents, the development of fertilized sea-urchin eggs.[4] Calcium ions prevent rhythmical muscular contraction, but allow the muscle to retain its irritability much longer than is possible in a solution from

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[1] Amer. Journ. Physiology, 3, 327 (1900).

[2] Ueber physikalisch-chemische Methode und Probleme in der Medizin, 19, Wien (1900).

[3] Loew, although attempting no such extensive generalization, has touched upon the question of ion proteids and their relation to vital phenomena in his discussion of the harmfulness to plants exhibited by magnesium salts in the absence of calcium. (See Bul. No. 18, Div. Veg. Phys. and Path., U. S. Department of Agriculture, p. 42, 1899.)

[4] Amer. Journ. Physiology, 3, 439 (1900).

which they are absent.[1] Results similar to those obtained by Loeb have recently been recorded by other investigators.[2]

That the converse case may also occur is indicated by Loeb's investigations: "Different combinations of ions may exist which all have the same effect. It seems as if the physical condition of the colloids were the essential point and that this might be affected by various ion combinations in the same way."[3]

It is not to be doubted that many peculiarities in relation to ions will likewise be discovered in plants as compared with animals. A case in point is that of magnesium chloride, which in pure solution is eight times as toxic as sodium chloride to roots of the white lupine and of alfalfa while the two salts are about equally toxic when calcium is present. Hence lupine roots react toward these two salts in a wholly different manner than do sea-urchin eggs. Furthermore, a comparison of different plants, one with another, or of different organs or stages of development in the same plant, will surely reveal numerous dissimilarities.

The importance of the ion-proteid theory as an aid to the study of the effects, both toxic and beneficial, which solutions of electrolytes induce in organisms, can hardly be overestimated. It is to be regarded as the only really scientific explanation of this class of phenomena which has yet been attempted. Incomplete as the theory is in its present form, and many as are the anomalies needing further study, we can not but welcome it as a most promising instrument wherewith to attack the vast problem of the physical properties and energies of protoplasm.[4]

Meanwhile it is highly desirable that the study of ion action upon plants be extended. Experiments should be made with a larger number of different ions, and with mixtures containing more than two kinds of cathions.[5] It is most essential that many species of plants be tested in order that we may determine what classes of reaction to ions are peculiar to certain groups of organisms and what, if any, may

[1] Festschrift für Adolf Fick, p. 111 (1899).

[2] See the papers of Garrey, Anne Moore, Cushing, Lillie, and Stiles cited in the Bibliography, (p. 56). True has lately experimented with *Cladophora gracilis* grown in various synthetic solutions resembling sea water, and has made the highly interesting discovery that an indefinite prolongation of life could be obtained only when a solution equivalent to sea water in its other components, but containing much more NaCl, was employed. Addition of calcium and potassium salts was found necessary in order to neutralize effectively the toxic action of a sodium salt solution.

[3] Amer. Journ. Physiology, 3, 443 (1900).

[4] For certain limitations of the theory as now formulated reference should be made to the very important paper of Kahlenberg [Journ. Physical Chem., 5, 339 (1901)].

[5] Loeb's discovery that fertilized eggs of the sea urchin could be developed to the pluteus stage in mixtures of three, but not of two chlorides, indicates that much is to be expected from such an extension of these investigations. See Amer. Journ. Physiology, 3, 441, (1900).

be regarded as generic properties of protoplasm. No less important, as Loeb's work with animals has conclusively shown, will be the comparative study of different organs and functions and stages of growth in the same plant, as to their different reactions to the same ions and combinations of ions.

From the point of view of agriculture the ion-proteid theory will doubtless throw light upon much that is now obscure and even paradoxical in the relation between the plant and the soluble components of the soil. Nothing is more certain, in the light of such observations as are recorded in this paper, than the inadequacy of soil physics and soil chemistry alone to explain many details of this relation. The chemistry of protoplasm and its proteid compounds must surely be taken into account before we may hope to get to the bottom of the subject.

## STIMULATING EFFECT OF DILUTE SOLUTIONS.

As an incident of these investigations it was demonstrated that in the case of certain salts, when plant roots are exposed to pure solutions which are much too dilute to produce any toxic effect, there occurred a decidedly stimulating effect upon growth, as compared with that in the distilled-water control during a corresponding period. As would be expected, this was shown to be the case for salts of calcium, both the chloride and the sulphate acting as stimuli. Here, however, we have to do with salts which contain valuable elements of plant food.

But a marked stimulating action occurs in pure solutions of sodium carbonate (slight in 0.002 normal, marked in 0.00125 normal and of sodium bicarbonate 0.01 normal). The most pronounced effect was obtained in a 0.00125 normal solution of sodium carbonate, the average elongation of the roots in that solution being one and one-half times as great as in distilled water during the same period. In the case of the two carbonates of sodium it seems necessary to regard the effect as one of chemical stimulus, pure and simple. That this is not due to the sodium ions is evident from the fact that very dilute solutions of other sodium salts (sulphate, chloride) gave purely negative results. It was at first thought that the physiological effects of sodium carbonate ($Na_2CO_3$) were attributable to the presence of hydroxyl ions in the solution, since the corrosive, clearing action of more concentrated solutions of this salt is precisely similar to that produced by potassium hydrate and sodium hydrate. But toxic, as well as stimulating reactions of exactly the same character were obtained with solutions of the bicarbonate ($NaHCO_3$), in which a large excess of carbon dioxide was dissolved, and which gave no reaction with phenolphthaleine, even at the end of the experiment.[1] In this case the consideration of free hydroxyl

[1] Solutions of sodium carbonate which were many times too dilute to produce a stimulating effect, yet gave a strong reaction with phenolphthaleine.

ions must be excluded. Hence the conclusion seems unavoidable that the carbonic acid ($HCO_3$) ions produce the stimulating effect, improbable as this would appear. To what agency should be ascribed the characteristic toxic action (so different in kind from that of sodium sulphate and sodium chloride) of stronger solutions of sodium bicarbonate, in which no free hydroxyl could be detected, is a question to which no answer can at present be given.[1]

None of the other salts with which experiments were made in pure solution were shown to stimulate elongation of the roots, although the possibility is not excluded that solutions still more dilute than those employed will give positive results. Magnesium sulphate was found to be indifferent (neither toxic nor stimulating) at 0.0003125 normal, magnesium chloride at 0.000625 normal, sodium sulphate (nearly) at 0.002 normal, and sodium chloride[2] (approximately) at 0.005 normal.

These observations accord with the well-known principle that many violent poisons, if given in sufficiently minute doses, serve as beneficial stimuli. Familiar examples are the action of arsenic, mercury,

[1] In experiments with sodium carbonate and sodium bicarbonate as to their effect upon animals, Loeb encountered a very similar anomaly. The stimulating effect of various hydrates upon the absorption of water by a muscle immersed in a sodium chloride solution was shown to be clearly due to the hydroxyl ions, being equal in amount when equivalent solutions of hydrates were used, irrespective of the character of the basic ions [see Pflüger's Archiv, 69, 10 (1898)]. The similar effect produced by carbonates of sodium and potassium was ascribed to the same factor, the hydroxyl ions (l. c., p. 20). On the other hand, the effect of sodium carbonate ($Na_2CO_3$) in stimulating skeleton formation in the pluteus of a sea urchin appears to be due to the carbonic acid ($HCO_3$) ions, since sodium in other forms, as well as hydroxyl in the form of potassium hydrate, gave negative results [Am. Journ. Physiology, 443, (1900)].

[2] Pfeffer [Pflanzenphysiologie, Ed. 2, 1, 425] observes that possibly chlorides (e. g., sodium chloride), like so many other substances, act in dilute solutions as chemical stimuli. Storp [Biedermann's Centralbl., 13, 76 (1884)] obtained a stimulating effect upon the germination of seeds by immersing them in a 0.01 per cent solution of sodium chloride. Jarius [Landw. Versuchsst., 32, 149 (1886)] found that even a 0.4 per cent solution of sodium chloride stimulated the germination of seeds of wheat, rye, rape, maize, beans, and vetches. Jones and Orton (Bul. Vermont Agric. Exp. Station No. 56, p. 12) observed, as a consequence of the application of sodium chloride to land in order to exterminate the weed known as Orange Hawkweed (*Hieracium aurantiacum*), a marked stimulating effect upon the growth of grass in the same field. Peligot [Comptes rendus, 73, 1078 (1871)] suggests that the stimulating effect upon field crops which is sometimes obtained with sodium chloride may be due to its facilitating the decomposition of calcium phosphate and thus increasing the amount of phosphoric acid at the disposal of the plant. Kellner [Landw. Versuchsst., 32, 365 (1886)] attributes to a similar liberation of phosphoric acid the stimulating effects of iron sulphate upon plant growth recorded by Koenig and by Griffiths (see p. 49). Réveil [De l'action des poisons sur les plantes, p. 41 (1865)] found that sodium hypochlorite in a solution of 0.1 per cent stimulates germination and growth, but is injurious, especially to herbaceous plants, when applied in greater concentration.

strychnine, digitaline, etc., upon animals. Numerous investigators have obtained similar effects with plants by supplying them with very small quantities of various substances which can not be regarded as sources of plant food, such as the extremely toxic salts of some of the heavy metals. In practically all such cases, however, it is very probable that considerable hydrolysis had taken place and that the stimulation might well be attributed to the hydroxyl ions thus introduced into the solution.

Raulin experimented extensively with the fungus Aspergillus as to the effect of various metallic salts in stimulating or hindering its growth, his being among the first considerable work in this line.[1]

The well-known observations of Frank and Krüger[2] indicate that copper in small quantities (furnished by spraying with Bordeaux mixture) stimulates the growth of the potato, acting favorably upon almost every organ and function, although this metal is well known to be

[1] Ann. Sci. Nat., sér. 5, 11, 243 (1869).—The sulphates of zinc and of iron were found to produce marked stimulating effect, the former increasing the dry weight of the fungus two to three or even seven times, the latter about twice. In order to show that the acid radicle was not responsible for the results, a corresponding amount (0.06 gram of salt per 1,000 grams of culture solution) of ammonium sulphate was tried, but no stimulation was obtained. To demonstrate still more completely that basic radicles are here chiefly concerned other salts (nitrates of iron and of zinc, zinc acetate, iron citrate) were tried and yielded stimulative effects similar to those of sulphates. In cases where both iron and zinc were added to the same culture solution (e. g., zinc nitrate plus ferric citrate, or ferric sulphate plus zinc acetate, or zinc acetate plus ferric citrate) the stimulating effect was decidedly more marked than when only one base was used. When sulphates of both zinc and iron were present the effect was nearly twice as great as in the absence of the former, and was exactly twice as great as in the absence of the latter. The diminution of the stimulating effect was almost as great if instead of merely withdrawing one or the other base an equal portion of the second base was substituted for the first; in other words, when two parts of zinc (or of iron) were substituted for one part each of zinc and of iron. The stimulating effect of the different salts of zinc expresses itself in a crop from two to four and six-tenths times, that of iron in a crop one and four-tenths to two and seven-tenths times as great as in the pure culture solution.

Manganese was found to produce effects similar to those of iron and of zinc, but "less constant, less appreciable." Silica (as silicates of potassium and of sodium) when added to the culture solution increased the dry weight of Aspergillus in the ratio of 1.2 or 1.4 to 1.

Raulin wrongly concluded that zinc and silica are indispensable to this fungus, but justly emphasizes "this influence of infinitely small quantities of substances upon vegetation" (l. c., p. 253).

J. Koenig [Landw. Jahrb., 12, 837 (1883)] and Griffiths [Journ. Chem. Soc., 1884, p. 71, and 1885, p. 46] obtained evidence of a stimulating effect of iron sulphate upon the growth of plants by watering soils used in culture experiments with a solution of this salt. On the other hand Kellner [Landw. Versuchsst., 32, 365 (1886)], following the same method of experiment, obtained only negative results.

[2] Ber. d. deutsch. bot. Gesellsch., 12, 8 (1894).

extraordinarily poisonous to plants.[1] Miani[2] records the interesting observation that in a vapor-saturated chamber the mere presence of copper in the neighborhood of but not in contact with a hanging drop of water containing spores of Ustilago and pollen grains of various plants stimulated the germination of the latter. H. Schulz[3] found that alcoholic fermentation is accelerated by the presence of a small quantity of mercuric chloride and of other substances. The development of Aspergillus and of Penicillium in glycerol cultures was stimulated, according to Pfeffer,[4] by the presence of small quantities of zinc, manganese, cobalt, etc. Subsequently numerous experiments as to chemical stimulation were made by Richards upon fungi.[5]

[1] For a classical discussion of the toxic effect of exceedingly dilute solutions of metallic salts upon the alga Spirogyra, see Nägeli, Neue Denkschr. schweizerischen Gesellsch. f. gesammt. Naturw., **33** (1893). Copper in a solution of 1 part to 1,000,000,000 of water was found to be fatal! (l. c., p. 23.) Attention has lately been redirected to the extreme toxicity of copper by Dehérain et Demoussy [Comptes rendus, **132**, 523 (1901)] and by H. Devaux (l. c., p. 717). The latter's observation that protoplasm absorbs less copper when exposed during several hours to a large quantity of a running very dilute solution (e. g., of 1 part copper to 400,000,000 parts water) than when placed for a short time in a single drop of a much more concentrated solution (1 part copper to 30,000 parts water) leaves wholly unexplained the negative results as to the extraordinary toxicity of this substance recorded by Miani [Ber. deutsch. bot. Gesellsch., **19**, 461 (1901)], who immersed his subjects for a long period in a single drop of solution. Nägeli's experiments have been more recently repeated (upon Spirogyra and other organisms) by Israel und Klingmann [Virchow's Archiv, **147**, 293 (1897)], who made careful studies of the "oligodynamic" effects produced by extremely dilute solutions of copper. A noteworthy contribution to this subject by Galeotti has lately appeared [Biol. Centralbl., **21**, 321 (1901)], in which the effect produced by a "colloidal" solution of copper [prepared after the electrical method recently described by Bredig and Müller in Zeitschr. für physik. Chemie, **31**, 258 (1899)] is compared with that of an "ionic" solution of copper sulphate containing an equivalent amount of copper. This author found that the former (colloidal) solution plasmolyzed the protoplasm of Spirogyra in a dilution (1 gram-atom copper in 12,600,000 to 126,000,000 liters of water) at which the ionic solution (of copper sulphate) produced no effect whatever. He therefore concludes that the action of the colloidal solution is a catalytic one, closely analogous to the catalyzing action of such colloidal solutions (of copper and other metals) upon hydrogen superoxide.

[2] Ber. deutsch. bot. Gesellsch., **19**, 461 (1901).

[3] Pflüger's Archiv f. die gesammte Physiol., **42**, 517 (1888).

[4] Jahrb. für wiss. Botanik, **28**, 238 (1895).

[5] Ibid., **30**, 665 (1897). Richards experimented with sulphate of iron and with salts of zinc, cobalt, nickel, and manganese, as well as other substances, using as subjects one species each of Aspergillus, Botrytis, and Penicillium. The estimation of the amount of stimulus obtained was based upon the increase in dry weight of the whole mass of mycelium in the culture as compared with that in a control free from the stimulating substance. Zinc sulphate was found to be the most powerful stimulant, while important results were also obtained with sulphates of iron, cobalt, and nickel. Salts of lithium were likewise very effective. It was found, however, that acceleration of the development of the mycelium was accompanied by an unfavorable influence upon the production of conidia, when salts of zinc or of iron, amygdaline, or morphine were added to the culture solution. In other words, a stimulation of one function or phase of development does not necessarily imply stimulation of the organism as to all its functions.

Recently an important paper upon the effect of certain chemical stimuli upon fungi and algæ has been published by Ōno.[1]

Similar results as to the stimulation of life processes afforded by the presence of small quantities of various non-nutritive substances have been obtained in experiments with animals. Loeb[2] found this to be true of certain acids, hydrates, and mineral salts, the accelerating effect produced by the solutions upon the absorption of water by muscles, the rhythmical contraction of muscles and the segmentation of eggs being attributed to hydrogen ions, hydroxyl ions, or different basic cathions, as the case may be.[3]

The as yet obscure problem of the mode of action of chemical stimuli as regards plants has been discussed by Pfeffer,[4] from whom it may be permissible to quote at some length:

"In the regulation of activity chemical stimuli certainly play a very extensive part. It is obviously a matter of chemical stimulation that the seeds of Orobanche and of Lathræa germinate only upon the roots of host plants, and probably the same occurs with fungi. In the case of initiatory or only regulatory stimuli, there may be partly involved substances which the organism does not necessarily require. In fact, under certain circumstances very different substances can cause an acceleration of activity. * * * These and similar phenomena obviously arise from different causes. Partly it may be a matter of physiological counter reactions, which can also, for example, occasion an increase of respiration, of circulation of the protoplasm, etc., in response to injurious or other action. In other cases a more simple chemical acceleration of reaction may be concerned, as in catalytic action."

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[1] Journ. Coll. Sci. Univ. Tōkyō, 13, 141 (1900). This author experimented with various species of algæ and fungi in order to determine their reaction to minute quantities of the sulphates of zinc, nickel, iron, and cobalt as well as to sodium fluoride, lithium nitrate, and potassium arsenate. He found a marked increase in the total amount of vegetable matter produced in the presence of any one of these substances, the increase in the case of algæ being due, however, to the stimulation of vegetative reproduction rather than to any marked increase in the size of individual plants. The optimum dose for algæ is considerably smaller than that for fungi, 0.0001 gram molecule in most cases proving toxic to the former. Zinc sulphate exerts the greatest stimulating effect. These salts (especially $ZnSO_4$ and NaFl) tend to hinder the development of spores in fungi. Copper sulphate and mercuric chloride stimulate the growth of fungi, but not of algæ.

[2] See all the papers of this author cited in the Bibliography.

[3] It is probably worth while at this point to call attention to the fact that in nearly every case where this stimulative effect has been observed, electrolytes have been used which are known to show marked hydrolysis, with the formation either of hydroxyl ions, or more generally, as in the case of salts of the heavy metals, of hydrogen ions. And it may well be that, as in the studies of Loeb, the stimulating effects observed by former investigators may rightly be ascribed in the majority of cases to the presence of these ions.

[4] Jahrb. für wiss. Botanik, 28, 238, 239 (1895).

In another work[1] Pfeffer emphasizes the idea of counter reactions, suggesting that "one has to do in this accelerating stimulation with one of the manifold reactions which serve, through more intensive activity, to counteract as far as possible an injurious influence or to compensate injuries." And again:[2] "Probably this [stimulating] effect results from a general reaction of the organism against injurious substances, since similar effects are induced by ether, alkaloids, etc., effects which also find expression in an increase of fermentation and respiration. * * * It is easy to understand * * * that furthermore such substances as are poisonous only in higher concentration generally occasion no obvious [stimulating] effect."

If it can be shown that such stimulating effect is sufficiently permanent to express itself in a marked increase in the yield of a crop, its economic importance would be obvious. That the presence of a certain amount of calcium salts in the soil may really act as a chemical stimulant to growth, apart from the value of the salts as plant food, or in rendering soluble other nutritive soil components there appears to be some reason to believe. It is not impossible that other substances, even perhaps those salts of magnesium and of sodium which constitute the most noxious components of alkali soils, when present in quantity too small to be harmful, may be actively stimulative rather than merely indifferent to plants. That several of them are likewise valuable as sources of nutritive material is well known. Whether, after all, the distinction between the chemically stimulating effect and the utility as food of certain mineral salts be always as sharp as is commonly supposed, is a question which can not yet be regarded as decisively answered.

## ECONOMIC IMPORTANCE OF THE RESULTS.

Some of the facts ascertained by these experiments with salt solutions in their effect upon plants have a direct practical bearing upon agricultural conditions and methods in regions where alkali salts are frequent. Attention is particularly directed to the effects obtained by the addition of lime salts to others. Each of the common soluble alkali salts is found to be very injurious when alone, but usually much less harmful when two are mixed, especially when a salt of lime is one component of the mixture. This is strikingly the case with sulphates of magnesium and of sodium, the noxious effects of these salts being enormously lessened by the application of lime, particularly in the form of gypsum or land plaster (the dihydrate of calcium sulphate). Contrary to the general impression, this corrective effect was found in water-culture experiments to be considerably less for "black alkali" (sodium carbonate) than for any of the "white alkali" salts, although even the harmfulness of black alkali can certainly be greatly diminished by the use of gypsum.

[1] Pflanzenphysiologie (Zweite Auflage), 1, 374 (1897).
[2] Ibid., p. 409.

The soluble chloride of lime could apparently also be used to advantage upon a soil which is strongly impregnated with alkali. With this salt the best effects would be anticipated when it is used as a remedy for black alkali, although it is likewise a powerful antidote for the chloride and sulphate of soda and of magnesia. But, except in rare instances, the use of chloride of lime upon a large scale is hardly practicable. The little-soluble carbonate of lime is likewise more or less beneficial in all cases except that of black alkali, but it is a much less powerful remedy than is land plaster (calcium sulphate).

Much economic value should attach to an extension of these experiments by using mixtures of more than two salts. It would thus be possible to imitate more closely the conditions which obtain in alkali soils, where several or all of these salts usually occur together. Furthermore, other kinds of plants should be tried in order to determine to what extent plants differ one from another in their power to resist the effect of various combinations of alkali salts. In this connection experiments should be made with wheat, barley, sugar beets, and other important crops of the region, as it may be found that one crop is better adapted than another to withstand the effects of this or that type of alkali soil.

This leads to the possibility of selecting alkali-resistant breeds of each of the leading crops. By observation of a stand of wheat or of alfalfa which has been injured by the "rise of alkali" or by the use of alkaline irrigating water, it is usually possible to find here and there individual plants which have succeeded in surviving the injurious effects of the salts. Similar differences in the power of individuals to resist the action of alkali salts was detected in the culture experiments. By continued selection of the seed of such resistant individuals, sowing it season after season in alkali soil, there is reason to hope that in time a race could be developed and fixed which would flourish in soils containing a greater amount of alkali than can be endured by the ordinary agricultural varieties.[1] It will likewise be very interesting to determine whether a race bred to resist black alkali, for example, will also prove to be proportionately resistant to white alkali, or whether it will be possible and desirable to develop different races to suit different types of alkali soil. An observation already cited (see p. 34) would indicate that the different power of resistance possessed by individuals of the same species of plant is brought out

[1]Observations made by Roos, Rousseaux, and Dugast [Ann. de la Science Agron., sér. 2, 6ième année, 2, 336 (1900)] indicate such differences among the grapes cultivated in Algeria. It was found that of different varieties growing in the same soil the fruit of some absorbed less sodium chloride from the soil than was taken up by others. As the sale of wine containing too high a content of sodium chloride is prohibited by law in France, the economic importance of this discovery is obvious. Although the problem here involved is somewhat different from that of the power of resistance to the poisonous effects of a salt upon the plant, it serves to illustrate the general principle that different individuals or races show marked dissimilarity in their behavior in the presence of a given soil component.

more sharply in the presence of the carbonates of soda than when other "alkali" salts are concerned.

So great appears to be the promise of results to be obtained by breeding alkali-resistant races of the more important field crops of the far western United States, that the Department of Agriculture has already undertaken work on this line. During the past season experiments with this end in view were begun under the direction of Mr. Webber, of the Plant-Breeding Laboratory, Division of Vegetable Physiology and Pathology. It is hoped that they will demonstrate the practical value of this method of approaching the problem.

## SUMMARY.

As the result of these preliminary studies, the following facts can be regarded as established:

(1) Those readily soluble salts of magnesium and of sodium which are characteristic components of alkali soils are exceedingly injurious to plants when exposed to pure solutions of them of concentration above a minimum which is specific for each.

(2) They are toxic in the following sequence, beginning with the most harmful: Magnesium sulphate, magnesium chloride, sodium carbonate, sodium sulphate, sodium chloride, and sodium bicarbonate.

(3) Calcium chloride in pure solution is ten times less injurious than sodium chloride, and two hundred times less injurious than magnesium sulphate, if chemically equivalent solutions are considered.

(4) Magnesium carbonate in a saturated solution is not markedly injurious, while magnesium bicarbonate in saturated solution acts as a strong poison. Calcium carbonate and calcium sulphate are positively stimulating in saturated solutions, while calcium bicarbonate appears to be decidedly injurious.

(5) The toxic effect of the injurious salts is due very much more to the influence of the cathions (derived from the basic radicle) than to the anions (furnished by the acid radicle).

(6) By mixture of equal volumes of two readily soluble salts, or by the addition of a solid excess of a relatively insoluble to a solution of an easily soluble salt, the toxic effect of the more harmful component can in a majority of cases be diminished, or the concentration of the more toxic salt endurable by the roots of plants can be increased.

(7) This increase is much greater in cases where a different kind of cathion is added to the solution than when a new anion only is introduced.

(8) Addition of sodium ions to a solution containing magnesium ions in most instances markedly weakens the toxic action of the latter.

(9) Addition of calcium ions to solutions containing either sodium or magnesium ions nearly always counteracts to an extraordinary degree the injurious effect of the sodium or magnesium ions, this beneficial influence being usually much more marked when calcium is furnished as the sulphate than when the chloride is added.

(10) The ameliorating effect of calcium sulphate is much more marked when it is added to sulphates of magnesium and of sodium than when it is mixed with the corresponding chloride. It raises the concentration limit endurable by plant roots in magnesium sulphate four hundred and eighty times, in sodium sulphate more than sixty times.

(11) Even plasmolysis, although supposedly a reaction to purely physical stimuli, can apparently be completely prevented by altering the chemical nature of a solution without materially diminishing its osmotic pressure. At any rate, plasmolysis was not detected in cases where a solid excess of calcium sulphate had been added to a 0.3 or even 0.4 normal solution of magnesium sulphate, although a pure solution of magnesium sulphate is very strongly plasmolyzing at the concentrations named.

(12) Calcium chloride appears to be peculiarly effective in neutralizing the effect of sodium carbonate.

(13) The effect of one kind of ion in counteracting the physiological action of another kind can not be entirely explained by a study of the chemistry of the solution itself, but must in part be referred to complicated changes in the protoplasm of the organisms. The theory that ions furnished by the dissociation of electrolytes form intimate combinations with the proteids of protoplasm, and that their mutually antagonistic effect expresses itself in a replacement of one kind of ion by another as a result of change in the composition of the surrounding solution, would appear to afford the key to this problem.

(14) At a certain degree of dilution all of these salts become indifferent (i. e., neither toxic nor stimulating) in their action upon plant tissues. The maximum concentration of the indifferent solution is likewise specific for each salt.

(15) At a still greater dilution some of them, as the salts of calcium and the two carbonates of sodium, produce a positively stimulating effect upon the growth of roots.

(16) Individual plants show a marked dissimilarity in their power of resistance to the toxic action of the alkali salts. Such individual differences are strikingly accentuated in solutions of sodium carbonate and of sodium bicarbonate of the maximum concentration which will permit any of the roots to retain their vitality.

## CONCLUSION.

Too great stress can not be laid upon the fact that the experiments upon which the present report is based are merely preliminary. Furthermore, they were designed primarily to afford a standard for comparison of the salts involved. It is not to be expected—indeed, it is assuredly not true—that in the soils containing these salts the conditions are quite comparable to those maintained in the laboratory in the course of these investigations. The physical nature of the soil, as well as the presence of various other soluble substances, renders it

certain that nowhere in the field will these salts be found to have anything like the poisonous effect which they severally exert upon the roots of plants immersed in water solutions. Nevertheless it is only from such experiments, conducted under simplified conditions, that we can draw conclusions as to the actual effect of the components of alkali soils upon plant growth.

It is very desirable that this line of investigation be continued and extended. Further combinations, perhaps of more than two salts, should be tested; an attempt should be made to imitate as closely as possible natural soil conditions; plants in different stages of growth should be tried, for in irrigated regions it often happens that a standing crop is exposed to a varying soil content of soluble salts at different periods of its development. Finally, it is highly important that the experiments be repeated with other plants of widely different relationship and, as far as possible, of actual agricultural importance in the region concerned. For while we may assume for the present that the same sequence of harmfulness of the several salts will obtain in the case of most or all ordinarily cultivated plants, this is open to doubt, and it is quite certain that the actual limits of endurance differ in the case of different plants.

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[1] An extensive bibliography of the earlier literature of the subject is given by this author (pp. 169 to 176).

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# FORMATION OF SODIUM CARBONATE, OR BLACK ALKALI, BY PLANTS.

By FRANK K. CAMERON.

## INTRODUCTION.

Considerable attention has been paid within the past few years to the possibility of growing valuable forage crops on some of the alkali soils of the arid West. This subject was first taken up in California.[1] The great value of saltbushes for certain soil conditions and for certain kinds of cattle feeding seems to be well established, but as both Hilgard and Goss[2] have pointed out there is an element of danger, expressed in the prevalent belief that most of these plants, including the greasewood, chico, and other indigenous plants, convert the less harmful neutral salts, such as sodium chloride and sodium sulphate, into alkali carbonates—that is to say, the less harmful "white alkali" is converted into the more noxious "black alkali," as has been shown by the presence of sodium carbonate immediately under such plants, whereas no trace of it exists some distance away. It may be possible that the plants with their enormous root systems actually gather up minute traces of sodium carbonate, which may be present in lower depths of soil, gradually causing an accumulation at the surface on the decay of their roots and branches. But the generally accepted hypothesis of the conversion of the neutral salts appears more probable, as will be seen in the course of this paper. It would seem probable that plants growing in bunches or mats would be more effective in producing these localized black-alkali spots, but some of the most striking illustrations of this phenomenon have been observed in connection with more upright species, such as *Sarcobatus vermiculatus*, the common "greasewood" of the West.

In the study of the alkali soils of the arid regions the field parties of the Division of Soils have found the local flora of great value in indicating the character of the particular soils where they are found. This apparent relation between the plant and the salts present in the soil became of interest in this connection and was referred to the

[1] University of California, Agricultural Experiment Station, Bul. No. 125 (1899).

[2] New Mexico College of Agriculture and Mechanical Arts, Agricultural Experiment Station, Bul. No. 22, p. 41 (1897).

laboratory for consideration. The results of some preliminary investigations have proved of such interest as to warrant immediate publication.

CREOSOTE BUSH.

A specimen of the creosote bush[1] (*Covillea tridentata*) was examined. This, while a desert plant, is said to shun soils where there is much water-soluble salts. Mr. Means states that its presence can be taken as a sure indication of land free from injurious quantities of alkali. It is found in dry, well-drained upland soils.

The material was thoroughly air dried. The leaves and stems were then carefully separated, and both of the separated samples were ground fine in an agate mortar. A portion of each sample was burned to ash. The finely ground air-dried material and the ash were each carefully leached with successive small portions of water until the leachings ceased to show the presence of chlorides. The leachings in each case were then brought together and made up to a volume of 500 cubic centimeters, and the various determinations were made with 100 cubic centimeter portions. The carbonates[2] were determined by titrating with a twentieth normal (N/20) solution of hydrogen potassium sulphate until loss of color, using phenolphthaleine as indicator. So soon as the color had disappeared a drop or two of a solution of potassium chromate was added and the chlorine determined by titrating with a tenth normal (N/10) solution of silver nitrate. The sulphates, when determined, were estimated gravimetrically as barium sulphate in the usual manner. For convenience the acids thus found to be present are stated as the corresponding sodium salts. This procedure seemed to be justified by a subsequent determination of the amount of sodium present in the solution. It is a well established fact, and a familiar one to chemists, that when a salt of an alkali metal is burned down with charcoal or other organic matter a part of the mineral acid is volatilized and driven off, the alkali base forming a carbonate, which is a stable compound even at quite high temperatures. Nevertheless this is a point often overlooked in the discussion of ash analyses. In obtaining the ashes the examinations of which are described in this paper, very great care was exercised to reduce the amount of this loss of the mineral acid as far as possible, and the burning was done at as low a temperature as possible. In some cases the large amount of fused salt in the burning ash coated the charred organic matter in such a way as to render further combustion at a comparatively low temperature quite impossible. In these cases the combustion was stopped, the fused salts leached out with water, and the residue reburned. It seems probable, as will appear from the results which will be presented, that the loss of mineral acids

[1] Collected by Mr. Thos. H. Means near Tempe, Ariz.; kindly identified for us by Mr. F. V. Coville.

[2] Report 64, Division of Soils, U. S. Dept. Agr. (1900); Amer. Chem. Jour., 23, 571 (1900). Bul. 18, p. 77, Division of Soils, U. S. Department of Agriculture (1901).

in the burning of the plant to ash was kept down to a very small percentage by following the procedure described.

The data obtained on examination of the ashes from the creosote bush are presented in the following table:

TABLE XII.—*Analysis of the ash of the creosote bush.*

| | Leaves. | Leaves and small stems. | Stems. |
|---|---|---|---|
| Weight of sample, grams | 8.5659 | 3.6942 | 6.6445 |
| Weight of ash, grams | .8282 | .3795 | .3710 |
| Ash, per cent of plant | 9.66 | 10.27 | 5.58 |
| $Na_2CO_3$, per cent of ash | 8.90 | 13.18 | 17.73 |
| NaCl, per cent of ash | 5.71 | 5.37 | 3.55 |
| $Na_2CO_3$, per cent of air-dried plant | .86 | 1.35 | .99 |
| NaCl, per cent of air-dried plant | .55 | .55 | .19 |

The dry leaves, which had been ground fine in a mortar, were extracted with distilled water at the room temperature in the manner described above. The extract failed to show the presence of either sodium carbonate or sodium chloride, but appeared to be slightly acid. An extract made by boiling the leaves with water also failed to show any chlorides or carbonates.

From the facts which have been presented it would appear that while the plant does contain chlorine there is no sodium chloride present as such, and therefore it is probable that the chlorine is in organic combination although nothing is definitely known of the presence of such combinations in plants. The sodium is largely in excess of the amount required to balance the chlorine as sodium chloride. This fact was shown by an actual determination of the sodium.[1] It would seem, therefore, that at least a large part of the sodium in the plant is in organic combination, possibly with some organic acid, and, on combustion or ultimate decay of the plant tissues, much sodium carbonate would be formed, as was found to be the case when the plant was reduced to ash in the laboratory.

It is interesting to note that the mineral constituents, as shown by the ash analyses, had accumulated in the leaves to about twice the amount in which they were held by the stems. The difference is very much less, however, if we consider only the water-soluble constituents in the ashes. Assuming, for the sake of argument, that the base in combination with the carbonic acid and chlorine as determined was entirely sodium, its distribution is shown by the following table:

TABLE XIII.—*Distribution of sodium in leaves and stems.*

| Part of plant. | Percentages calculated for ash. | | | Percentages calculated for air-dried plant. | | |
|---|---|---|---|---|---|---|
| | From $Na_2CO_3$. | From NaCl. | Total. | From $Na_2CO_3$. | From NaCl. | Total. |
| Leaves | 3.86 | 2.25 | 6.11 | 0.37 | 0.22 | 0.59 |
| Stems | 7.69 | 1.40 | 9.09 | .43 | .07 | .50 |

[1] Unfortunately it was not anticipated at the time this determination was made that the exact figure would be required in this discussion, and the data were not entered in the laboratory notebook and have been mislaid.

It appears that in the leaves there was about 2.7 times as much sodium as was necessary to balance the chlorine, while in the stems there was more than seven times as much of the base as the acid would require. This suggests the possibility that the chlorine was being eliminated through the leaves, probably in the form of some volatile compound, which may be the source of the odor from the plant. This idea is brought out somewhat more strikingly, perhaps, by noting that the analytical figures given above indicate that the total amount of water-soluble mineral constituents in the leaves is 1.19 times the amount in the stems, but that the amount of chlorine in the leaves is 2.75 times that found in the stems; from which it would appear that the chlorine was being concentrated in the leaves and, as has been pointed out, was there present, in all probability, in organic combination. This is a point which merits further attention, and it is hoped that it will be the subject of a more thorough investigation in the future.

## GREASEWOOD.

A more thorough examination of a specimen of greasewood[1] (*Sarcobatus vermiculatus*) was made. This is a typical "alkali plant," its presence being usually regarded as a good indication of much water-soluble material in the soil. Mr. Means reports that whenever he has observed it the soil generally shows the presence of sodium carbonate, the only exception being in Montana, where the soluble salts are entirely sulphates. It would appear that this latter statement warrants further examination of the locality mentioned.

The analytical results obtained from examination of the ashes follow:

TABLE XIV.—*Analysis of the ash of the greasewood plant.*

| | Leaves[1] and blossoms (1). | Leaves and blossoms (2). | Stems. |
|---|---|---|---|
| Weight of sample, grams | 10.6395 | 5.0000 | 10.6817 |
| Weight of ash, grams | 2.7505 | 1.1736 | .5274 |
| Ash, per cent of plant | 25.85 | 23.47 | 4.94 |
| $Na_2CO_3$, per cent of ash | 51.93 | 57.90 | 29.46 |
| NaCl, per cent of ash | 20.47 | 22.24 | 14.31 |
| $Na_2SO_4$, per cent of ash | 7.97 | ..... | 3.69 |
| $Na_2CO_3$, per cent of air-dried plant | 13.43 | 13.69 | 1.45 |
| NaCl, per cent of air-dried plant | 5.29 | 5.22 | .71 |
| $Na_2SO_4$, per cent of air dried plant | 2.06 | ..... | 1.18 |

[1] Owing to the relatively large amount of fused salts which coated the carbon or other organic matter, this latter could not be completely burned off when reducing such a large sample to ash.

Five grams of leaves and blossoms, by successive leachings with distilled water at room temperature until the leachings aggregated 2 liters, gave (1) 5.81 and (2) 5.68 per cent of sodium chloride. In both experiments the washings showed no trace of soluble carbonates, but were slightly acid. The residue from (1) after ignition gave a trace of sodium chloride and 0.04 per cent of sodium carbonate.

[1] Collected by Mr. Frank D. Gardner near Salt Lake, Utah.

By the method of Carius—that is, heating in sealed tubes with fuming nitric acid and silver nitrate—

(1) 0.2327 gram of leaves and blossoms gave 0.0310 gram AgCl, equivalent to 5.43 per cent of sodium chloride.

(2) 1.0759 grams of leaves and blossoms gave 0.1432 gram AgCl, equivalent to 5.43 per cent of sodium chloride.

From these results it would appear that the plant contains chlorine, but, within the limits of experimental error, all the chlorine is present as sodium chloride, which can be leached out with water at ordinary temperatures. This is probably true of the major part of the sulphates also, although this was not shown quantitatively. A striking feature is the much larger amount of ash from the leaves and blossoms than from the stems and the markedly larger percentage of the alkali salts in the ash of the former. The idea suggests itself that possibly this plant takes up and stores the salts and holds them as such until it is ready to use such part of them as it needs.[1] On the other hand, it may be, for all that we now know, that these salts are present as described only because the plants can not prevent their accumulation, and, so far from being an inherent feature of the plant's economy, it may be a most undesirable accident due to their peculiar environment, but an accident in spite of which these particular plants are able to survive.[2] But, as Schimper[3] has pointed out, this can not be true in all cases, as evidenced by the fact that halophilous plants show a tendency to take up more salts than nonhalophilous species, even when grown in nonsaline soils.

None of the chlorine, apparently, was in organic combination, this

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[1] Schimper [Indomalayische Strandflora, p. 12 (1891); Pflanzen-Geographie, p. 99 (1898)] has expressed the opinion that halophytes thrive on salty soils because of a peculiar physiological structure which enables them to reduce to a minimum the evaporation from their leaves and, in consequence, the absorption of the salt solutions in the soil through their roots. The salt content of their sap is thus kept below a certain concentration, although this concentration may, and often does, greatly exceed that which would be determined by "osmotic equilibrium."

Stahl [Bot. Zeitung, p. 139 (1894)] observes that only a few species, such as *Reaumuria hirtella*, described by Volkens [Die Flora der Aegyptisch-Arabischen Wüste, p. 27 (1887)], are known to be able to free themselves from the salt.

Diels [Jahrb. für wiss. Botanique, **32**, 316 (1898)] objects that Stahl experimented with cultivated plants and that the retarded root action noted by Schimper does not take place under natural conditions, and that, as a matter of fact, and probably through the agency of malic acid, most, if not all, the halophytes rid themselves of an excess of chloride. Diel's methods of experiment, as well as the conclusions which he draws from his own premises, are criticized by W. Beneke, Jahrb. für wiss. Botanique **36**, 179 (1901).

Directly bearing upon this hypothesis is an observation by Detmer [Bot. Zeitung, **42**, 791 (1884)] that "organic acids under the condition prevailing for the vegetable organism are in a position to decompose chlorides with a formation of free hydrochloric acid." See also, Osborne, Report Conn. Ag. Ex. St., 1900, p. 441.

[2] Contejean, Geog. Bot., p. 71.

[3] Schimper, Pflanzengeographie, p. 101 (1898).

plant being in striking contrast in this respect to the *Covillea tridentata* examined above.

Another interesting point is that the leachings of the air-dried leaves and blossoms must have contained about three times as much sodium as was necessary to balance the hydrochloric and sulphuric acids present in the plant. The total amount of sodium calculated from the ash analysis would be 8.32 per cent. A direct determination of the sodium made on an aliquot part of the leachings gave 8.55 per cent, while the amount calculated as necessary to balance the hydrochloric and sulphuric acids, as determined by the ash analysis, is 2.68 per cent. The residue after leaching contained practically no chlorine, sulphates, or carbonates. It would appear that in the burning of the plant or in its decay the sodium, which is probably present in organic combination, yields sodium carbonate as a decomposition product, and this in turn is found in the ash or débris. It seems probable that a large part of the chlorine which was originally taken up or at least held by the plant in the form of sodium chloride has been thrown off by the plant in some manner, the sodium being retained in organic combination.

## ABSORPTION OF MINERAL CONSTITUENTS BY THE PLANT.

Inspection of the analyses of the ashes of plants in general, whether leaves, stems, or in fact any part of the plant tissues, shows that there are more than enough base-forming elements to counterbalance the possible inorganic acids which the results indicate to be present. Moreover, the ashes are alkaline. It is still an open question as to how these bases, which appear in excess, or, more generally, how all the bases, are taken up and assimilated by the plants and what becomes of the acid radicals. While it is possible that some of the alkaline materials may have been absorbed by the plant in the form of carbonates as such, the amount thus absorbed will be relatively very little, for by obvious metathetical reactions or double decompositions there would be formed carbonates of the alkaline metals. These latter would be hydrolized in water to some extent, giving caustic solutions which would undoubtedly corrode the tissues of the plants. The question as to the disposition of the acid residues is then pertinent. Several possible explanations suggest themselves, which seem worthy of attention in this connection.

It is possible that chlorine, for example, which may have been in the acid radical, has been changed by the plant in such a way as to form organic substances, and that these organic substances may be exhaled by the plant as odors or exuded by the leaves or roots. Against the latter suggestion the experiments of Diels[1] indicate that the excretion of such substances by the roots is very improbable. On the other hand, the chlorine or sulphur may be retained in the plant tissues in organic combination in such form that they more or less

[1] Jahrb. für wiss. Botanique, 32, 316 (1898).

completely disappear on combustion, the organic combination volatilizing as such, or by decomposition yielding volatile products containing the chlorine or sulphur.[1] In evidence against this view are the results obtained in the examination of the sample of *Sarcobatus vermiculatus*, where it was found that the total amount of chlorine in the plant, as determined by the Carius method, in which there was afforded no opportunity for any of the chlorine to escape, was the same as the amount leached out of the ashes by water, within the limits of experimental error.

Another idea that presents itself is that the bases and acids are taken up by the plant in the form of salt solutions; that the plant selects and retains the bases and excretes the acid radicals in some manner as acids. It is noteworthy, in this connection, that it has been observed generally in the cases of water cultures that the nutrient solutions gradually become acid unless special conditions are introduced to prevent it. Occasionally, however, cases have been found where the culture solutions actually become alkaline.[2] The point of special importance in this connection is that either a base or an acid radical, more often the latter, is either rejected or ejected by the plant.

It seems to have been generally supposed that the acidity of these solutions was due to organic acids formed and excreted by the plant, but no satisfactory proof for this view has been adduced. The weight of evidence is now decidedly against this view. It is not at all difficult, from the point of view of the chemist, to construct a probable "mechanism" for the phenomena presented, supposing that the plant has selectively retained the basic constituents and excreted the acids, and that the acidity of the culture solutions is due to the free mineral acids. Diels's[3] investigations in this direction are particularly interesting. He found that certain halophilous plants, when placed in distilled water, steadily lost the sodium chloride they contained. He showed that the salt was not excreted as such,[4] and offers as a probable explanation that the greater amounts of malic acid—the formation of which is shown to be a usual accompaniment of growth in succulent plants, such as most of the halophytes are—decomposes the sodium chloride, forming sodium malate and hydrochloric acid, and this latter is possibly excreted by the roots.[5] The solutions become acid, but, on account of the experimental difficulties, it was not definitely proved that the

[1] It is not intended to imply that chlorine and sulphur may not play very different parts in the plant economy, but the general considerations advanced might be true for either of these or other elements.

[2] Witness the classical investigations of Stohmann, Sachs, and Knop, described by Johnson in How Crops Grow, p. 180.

[3] Loc. cit. See also Kearney, Contributions from U. S. National Herbarium, Vol. V, No. 5, p. 277 (1900); and Benecke, Jahrb. für. wiss. Botanique, 36, 179 (1901).

[4] This point was established as early as 1865 by Wolf, Landw. Versuchstt., 7 pp. 20, 211 (1865).

[5] See reference to Benecke on p. 64.

acidity was due to the presence of hydrochloric acid. It is intended that some experiments in this direction shall soon be made in the laboratory.

A somewhat simpler explanation than the one just described may be offered—simpler because it does not require that the plant must first take up the acid radical and then go through the reverse process of exuding it again. It is known with reasonable certainty that a certain amount of hydrolysis takes place in aqueous salt solutions, although the absolute amount may be, and with ordinary strong electrolytes usually is, very small indeed; nevertheless, it does take place to some extent, and it seems not impossible that the plants might show their selective properties in the solution, taking up the base more rapidly than the acid, the latter in consequence being left in greater proportion in the culture or soil solution. Of classical importance in this connection is the work of Kuhn,[1] who found that when maize was grown in a solution containing ammonium chloride, the ammonium residue was partly taken up by the plant and hydrochloric acid remained in the solution. In fact, there does not seem to be any inherent difficulty in supposing that the plant might selectively absorb any ion for which it might have a special predilection. As soon as this ion is removed from the solution the corresponding ion with its opposite charge of electricity must either be removed from the solution by precipitation or volatilization, for example, or it at once reacts with the water. Supposing the ion removed by the plant to be a base, the action of the remaining acid ion on the water must necessarily be accompanied by the liberation of oxygen from the water of the solution. Whether or not any observation of this kind has been made I do not know, but the liberation of the oxygen might very well take place so slowly as to escape detection. The question as to what becomes of the electrical energy on the ion which the plant absorbs will be answered in a consideration of the work energy, heat energy, or other equivalent forms of energy involved in the mechanism of the absorption process, and does not necessarily demand further consideration at this point.[2]

It must be admitted in all frankness that the known facts in our possession are not sufficient to justify a positive opinion as to the views just presented. They seem, however, to be founded on a rational basis and are put forward tentatively as suggestive of possible lines of investigation and the justification for formulating them here will be found in the results of future work. Whatever may be the bearing of this work on the ideas here presented, it can not fail to be of the utmost importance in throwing light upon the difficult problem of plant nutrition.

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[1] Henneberg's Journal, pp. 116 and 135 (1864).

[2] These views are not intended to imply that salts can not be taken up as such, even by nonhalophilous plants, under certain conditions. Wolf (loc. cit.) has long since shown that this may be done, and that, moreover, in such cases the process can not be a simple diffusion phenomenon.

From the data presented above it is evident that in the decay of wood or leaves or, in general, of plant tissues, alkaline carbonates are furnished to the soil. It may be that the processes of decay will furnish at the same time organic acids stronger than carbonic acid and in sufficient quantity to combine with all the bases and prevent an alkaline reaction. As has been shown in this laboratory carbonic acid itself may be formed in sufficient amounts to convert all the carbonates to the form of bicarbonates and thus prevent an alkaline reaction. There is not sufficient evidence to justify a positive statement, but it would seem probable that this can not be always the case and that in fact there is alkali formed by the decay of plant tissues. In humid regions the alkali thus formed is removed by leaching or similar processes and by chemical reactions with the other soil components, for which reactions water is necessary.

In the arid regions, such as are found in the western part of the United States, peculiar phenomena, due to the special conditions there existing, have been observed. The indigenous plants which are found on the alkali lands are comparatively few in number, both as to species and as to individuals; others have been artificially introduced. They all have the property of absorbing more or less large amounts of water-soluble mineral salts and on analysis all show characteristically large percentages of bases. When the leaves or débris from these plants have decomposed there is often found greater or less accumulation of carbonates, although before the plant was cultivated that particular region may have been quite free from soluble carbonates. The decay of any organic matter with the accompanying formation of carbonic acid in a soil containing soluble salts of the alkali metals must be expected to result in the formation of soluble carbonates, partly by dissolving lime or magnesium compounds, followed by subsequent metathetical reactions or double decompositions with the alkali salts; more slowly and in lesser degree, perhaps, but nevertheless surely, if the formation of carbon dioxide is continued, by a distribution of the base between the two acids. This last process, however, is probably of decidedly minor importance in the phenomena under consideration.

Owing to the conditions of climate and drainage existing in the arid regions these carbonates when formed are not leached away, as in the humid regions, and gradually accumulate to the more serious detriment of the soil.

### COMPARISON OF ANALYSES.

For the purpose of comparison, two analyses of greasewood (*Sarcobatus vermiculatus*) ash are here quoted, the first published by Hilgard,[1] and the other by Goss and Griffin.[2]

[1] University of California, Report of Agr. Exp. Sta., p. 142 (1890).

[2] New Mexico College of Agr. and Mech. Arts, Agr. Exp. Sta., Bul. 22, p. 41 (1897).

TABLE XV.—*Two analyses of ash of greasewood plant.*

| Constituents. | First analysis. | Second analysis. |
|---|---|---|
| | *Per cent.* | *Per cent.* |
| Ash of air-dried plants | 12.03 | 13.12 |
| $SiO_2$ | 11.81 | 3.00 |
| $K_2O$ | 18.53 | 22.06 |
| $Na_2O$ | 39.45 | 23.89 |
| CaO | 1.36 | 6.52 |
| MgO | 1.09 | 1.35 |
| $MnO_2$ | | Trace. |
| $Fe_2O_3$ | 7.06 | [1] 4.73 |
| $Al_2O_3$ | | |
| $P_2O_5$ | 3.51 | 4.12 |
| $SO_3$ | 4.93 | 4.33 |
| $CO_2$ | 0.46 | 23.80 |
| Cl | 15.04 | 8.01 |
| | 103.04 | 101.81 |
| Oxygen = chlorine | 3.25 | 1.81 |
| | 99.79 | 100.00 |

[1] By difference.

While these analyses differ considerably in details they indicate the same general conclusions; that is, the ash or decomposition products of the plant will yield a very large amount of alkali in the form of carbonates. The figures in Hilgard's analysis, he states, indicate the presence of about 25 per cent of sodium chloride; about 8 per cent of Glauber's salt ($Na_2SO_4 10H_2O$), and about 39 per cent sodium carbonate. Combining the figures of Goss and Griffin's analysis in the conventional way, we find about 13 per cent sodium chloride and 29 per cent sodium carbonate. The figures are misleading, for they depend upon an arbitrary calculation of the data as salts, and the effect of the other constituents can not properly be ignored. Similarly, but a qualitative comparison can be made from the data obtained by us. If it may be assumed that the leaves and stems are of equal mass in the individual plants when air dried, our results compare quite well with the analyses just cited.

Acknowledgments are due Messrs. F. D. Gardner and Atherton Seidell for assistance in the experimental work described.

## SUMMARY.

It would seem as a result of the experiments described in this paper that in certain cases at least a transformation of neutral salts to the corresponding carbonates through the agency of plant growth is possible and even probable, and that this factor must be taken under consideration in determining the value and use of such plants. Some tentative suggestions are offered as to the disposition of the mineral salts in plant economy, which it is hoped will lead to more exhaustive investigations.

# RESISTANCE TO BLACK ALKALI BY CERTAIN PLANTS.

By FRANK K. CAMERON.

## INTRODUCTION.

While working in the San Joaquin Valley, California, during this past summer one of the field parties of the Division of Soils observed three species of plants which appeared to be characteristic growths on soils containing much "black alkali" or sodium carbonate. Superficial examination in the field brought out the fact that the stems and leaves of these three plants were quite acid, in some cases very markedly so. A possible connection was suggested between this fact and the one first noted—that these plants were all found on soils containing much sodium carbonate. Specimens were collected and sent in to the laboratory for further examination. They were kindly identified by Mr. Kearney, of the Division of Vegetable Physiology and Pathology. They consisted of three samples of *Distichlis spicata*, numbered I, II, and III; one sample of *Suaeda intermedia*, which was separated into two portions, the first numbered IV, consisting of the stems alone, and the second numbered V, being composed of leaves alone; one sample of *Atriplex bracteosa*, which was also separated into a portion numbered VI, consisting of stems alone, and a portion numbered VII, consisting of leaves alone.

Samples I, II, and III were thoroughly air dried by being allowed to remain for about two months in the sacks in which they were received at the laboratory. It should be stated that a rough determination of the acidity they displayed was made as soon as they were received in the laboratory, and the results agreed fairly well with those obtained by the more careful examination subsequently made.

Samples IV, V, VI, and VII were found to be very wet and in serious danger of fermenting when received at the laboratory. They were therefore placed in a hot-air oven and dried for several days at from 105° to 110°C. In each case the material was then cut into small pieces and kept in carefully covered beakers, to which, however, the air had free access.

## METHOD OF EXAMINATION.

The method of examination was in all cases to steep the sample, which had been cut into small pieces about a centimeter in length, overnight or for about twenty hours in a convenient amount of dis-

tilled water. About 600 cubic centimeters of the supernatant solution was then decanted through a folded filter, and the analytical details carried out with 100 cubic centimeter portions of the filtered liquid. It was thought probable that this procedure would give a close approximation to the soluble salts on the plant or held in its tissues in the form of inorganic salts. The acid material on the surface of the plant was evidently quite soluble in water. It was concluded, as will be shown later, that it was an organic acid, and that in all probability considerable quantities of its sodium or other salts, as well as the acid itself, were on the surface of the plant and dissolved in the water. The amount of free acid was determined by titrating with a solution of potassium hydroxide, which in turn had been carefully standardized by titration against a twentieth normal (N/20) solution of acid potassium sulphate. The other determinations were made in the conventional way.

## DISTICHLIS SPICATA.

TABLE XVI.—*Distichlis spicata.*

| | Sample I. | | Sample II. | | Sample III. | |
|---|---|---|---|---|---|---|
| Grams of material | 13.12 | | 35.35 | | 29.48 | |
| Cubic centimeters of leachings | 750 | | 1,250 | | 1,500 | |
| Percentage (mineral matter) leached out | 4.52 | | 5.12 | | 5.73 | |
| Cubic centimeters N/20 acid equivalent to 1 gram substance | 23.08 | | 1.16 | | 2.48 | |
| | Percentage distribution. | Per cent in air-dried material. | Percentage distribution. | Per cent in air-dried material. | Percentage distribution. | Per cent in air-dried material. |
| Ca | 5.62 | 0.254 | 2.89 | 0.148 | 3.25 | 0.186 |
| Mg | 1.86 | .084 | 1.17 | .060 | 2.10 | .120 |
| Na | 41.30 | 1.867 | 33.12 | 1.696 | 27.24 | 1.561 |
| K | 13.40 | .606 | 9.70 | .497 | 12.23 | .701 |
| $SO_4$ | 4.38 | .198 | 4.69 | .240 | 2.72 | .156 |
| Cl | 33.44 | 1.511 | 48.43 | 2.480 | 52.46 | 3.006 |
| | 100.00 | 4.520 | 100.00 | 5.120 | 100.00 | 5.730 |
| $CaSO_4$ | 6.19 | .280 | 6.64 | .340 | 3.83 | .219 |
| $CaCl_2$ | 10.48 | .474 | 2.58 | .132 | 5.90 | .338 |
| $MgCl_2$ | 7.25 | .328 | 4.57 | .234 | 8.20 | .470 |
| KCl | 25.52 | 1.154 | 18.49 | .947 | 23.27 | 1.333 |
| NaCl | 15.22 | .688 | 57.08 | 2.922 | 52.03 | 2.981 |
| Na | 35.34 | 1.598 | 10.64 | .545 | 6.77 | .388 |
| | 100.00 | 4.520 | 100.00 | 5.120 | 100.00 | 5.730 |

TABLE XVII.—*Soil (0–12 inches) in which Sample I of Distichlis spicata was found.*

| | Per cent. | | Per cent. |
|---|---|---|---|
| Ca | 0.48 | $CaSO_4$ | 1.60 |
| Mg | .16 | $MgSO_4$ | .75 |
| Na | 33.77 | $Na_2SO_4$ | 5.50 |
| K | 1.81 | KCl | 3.47 |
| $SO_4$ | 5.44 | NaCl | 10.72 |
| Cl | 8.06 | $Na_2CO_3$ | 39.96 |
| $CO_3$ | 22.63 | $NaHCO_3$ | 38.00 |
| $HCO_3$ | 27.65 | | 100.00 |
| | 100.00 | Percentage soluble, 1 gram soil to 20 cubic centimeters water | 3.75 |

The analytical data obtained from an examination of the *Distichlis spicata*—Samples I, II, and III—are given in Table XVI. The most striking point brought out is the very large amount of acid shown to be on Sample I, amounting for 1 gram of the air-dried material to the equivalent of 23 cubic centimeters of a twentieth normal (N/20) acid. This substance was unquestionably an organic acid and a fairly strong one. It did not appear to act on crystals of calcite very readily. This might have been due, however, to the formation of a slightly soluble lime salt, which would protect the calcite from the solvent. The acid very readily decomposed the alkali carbonates and neutralized not only ammonium hydrate but potassium or sodium hydroxide in the presence of cochineal or phenolphthalein as indicator. It will be seen by referring to the analytical figures that a large amount of sodium is left after balancing the acids by the bases found. This would seem to find its readiest explanation in supposing that there was a much greater quantity of the organic acid on the plant than indicated by the equivalent of 23 cubic centimeters of twentieth normal acid, but present in the form of the sodium or other salts. By referring to the analysis (Table XVII) of the soil from which this Sample I of *Distichlis spicata* was taken, it will be seen that there was relatively a very large amount of soluble carbonates present, about 2 per cent of the soil being composed of these substances—an amount which would absolutely prohibit the growth of any ordinary plant, even though much of the salt was in the form of bicarbonate. Much of this material probably came in contact with the grass leaves, in the form of dust or otherwise, with the result that the acid decomposed the carbonates with the formation of salts of the organic acid. These same views seem to hold for Samples II and III as well, but to a lesser extent, as is shown by the quantitative measurements given.

It would appear from what could be learned in the field that this grass, in the locality from which Samples II and III were taken, often carries as much of the acid material as Sample I shows, or even more. Unfortunately for this investigation the most favorable season for securing samples had passed before Samples II and III were gathered and sent in. This subject will receive more careful attention during another field season.

### ISOLATION AND IDENTIFICATION OF ACID EXUDATION.

Careful attempts were made to isolate or at least to identify this organic acid, but the attempts proved unavailing for several reasons. But very little material was at command when the investigation was taken up. The relatively large amounts of inorganic salts obtained in the water extracts could not be well separated and presented great analytical difficulties in the attempts to isolate so small a quantity of the acid as was at our disposal. Attempts to crystallize the material from solution, either as the acid itself or as a salt, proved disastrous

on account of the rapid and abundant growth of fungi in the solution when evaporation of the solvent at ordinary temperatures was attempted. The solutions of the material failed to give any reactions by which it could be identified as one of the simpler and better-known organic acids. For these reasons efforts to identify it were abandoned temporarily and further work on it postponed until a time when a larger amount of the material could be obtained. It is confidently believed that the experience thus far gained will insure a successful issue to the next attempt in this direction.

### HYDROSCOPIC SALT ON THE PLANT SURFACE.

The analytical results would indicate that calcium chloride as such was on the grass, but if present no signs of it were observed on the air-dried material. The samples were all thoroughly dry and not the least evidence of any deliquescent substance on the surface was apparent. It should be remembered, however, that the evidence obtained in the examination of the organic acid indicated that the calcium salt was much less soluble than the sodium or potassium salt. In all probability the greater part of the calcium in combination in the solid phase and not in the form of calcium sulphate was present as the calcium salt of the organic acid; and the greater part of the sodium which was assumed above to be in combination with the organic acid was in reality in combination with the chlorine, which the analysis as stated assumes to be combined with calcium.

On the other hand, it has been noticed that this grass when growing in the field is frequently covered with a moist, sticky substance, which there is reason to believe is caused by moisture absorbed from the air by the salts, but only in sufficient quantity to partially dissolve them, making a paste or gummy mixture. So that it is not so improbable that calcium chloride is sometimes formed and is to be found as such on the living plant.

### SELECTIVE ABSORPTION OF SOIL CONSTITUENTS.

Another point brought out very strikingly by an examination of the analyses is the relatively large amounts of both calcium and potassium found in the leachings from the plants, when the proportion of these elements in the water-soluble portion of the soil is considered. These facts might possibly find an explanation in part in the lesser solubility of the calcium and potassium salts of the organic acid and the accumulation of such salts formed by contact of dust from the soil with the acid. But such reasoning does not afford an explanation of the enormously increased ratio between the chlor ions and the sulph ions found in the plant leachings as compared with the ratio of these substances in the soil. The relative absorptive powers of the plant for these various constituents are probably the controlling factors.

It would seem desirable to give earnest attention to this subject with plants grown under careful supervision in the field or laboratory, as the evidence here presented indicates that the removal or cropping of these plants for any purpose would result in taking from the soil enormous quantities of desirable plant food and the consequent raising of the proportion of undesirable elements in the soil.

### FUNCTION OF THE ACID EXUDATION.

When the large amounts of soluble carbonates found in the soils upon which these plants grow are considered, and when the disastrous corrosive action of this substance is remembered, the production of the strong organic acid by the plant seems a wise protective measure of nature. The tendency of sodium carbonate to outstrip other salts in accumulating in the very top layers or crusts of a soil and there corroding the root crowns of plants has been frequently noted by all investigators of alkali problems. It would seem that this organic acid is produced by the plant in the manner most favorable to its being brought into contact with the surface sodium carbonate, partly converting this latter to the sodium salt of the acid and partly, in all probability, to sodium bicarbonate, which, there is strong reason for believing, is not itself so harmful to plant growth as the normal carbonate.[1]

### PHOSPHORUS IN THE PLANT.

In the attempts to identify the organic acid on Sample I, *Distichlis spicata*, some leachings were obtained which contained a small amount of organic matter mechanically suspended, as well as some in solution. They were allowed to stand for several days in an Erlenmeyer flask, the mouth of which was covered with an inverted beaker. A rapid and voluminous growth of fungi was observed. On filtering off a small portion of the solution after it had been standing a day or two a decided though small amount of phosphoric acid was shown to be present. No trace of this substance was found in freshly prepared leachings of the plant. It would seem probable that it was formed as a result of the action of organisms either upon dissolved organic

[1] The especially pernicious effect on plants of carbonate of sodium is in all probability due to the fact that this salt readily hydrolizes in water with the formation of considerable amounts of sodium hydroxide, and it is this latter substance which is in reality responsible for its great destructive power. Sodium bicarbonate or hydrogen carbonate, $Na\text{-}HCO_3$, might be expected to hydrolize to some extent also, being composed of a strong base in combination with a weak acid; this would be equivalent to a partial inversion to the normal carbonate. But in the presence of so much carbon dioxide as is present in soils this inversion to the normal carbonate would be greatly retarded or altogether prevented. The normal dissociation of the hydrogen carbonate would then be very small indeed and any chemical activity of the compound depending on the formation of ions would be correspondingly small.

matter in the leachings or perhaps upon the organic matter mechanically suspended in the solution. From lack of material it was not possible to determine the amount of phosphorus in the plant, but the qualitative observations cited would indicate that it was present in considerable amount. It should be observed that it was a constituent of the readily water-soluble portion of the soil from which the plant was taken in very small amounts, if, indeed, it were present at all. Attempts to detect it by the phosphomolybdate method failed to show a trace. The remarkable ability of this plant to take from the soil solutions the mineral constituents it needed, in the presence of the enormous excess of other readily soluble substances, is brought out very strikingly in this connection.

For the reasons here presented it would seem that this plant is worthy of the serious consideration of the botanist and physiologist, and is undoubtedly of very great economic importance.

### ASH ANALYSES.

Ash analyses of all the plants considered in this paper were made, in the hope that some conclusions might be drawn as to the inorganic materials in the plants themselves, and as to how much, relatively, was capable of being removed by leaching. These analyses will not, however, be presented, for it is obvious that they have no value whatever for the purposes here indicated. The mixture of salts on the plants was so large in amount, and fused at so low a temperature, that it quickly coated the organic matter, so that it was necessary to heat to a very high temperature and thoroughly stir the mixture to obtain anything like a thorough combustion of the organic material. This resulted in a very great loss of the salts by volatilization, sodium chloride and potassium chloride being especially important in this connection. Further, the burning of either sulphates or chlorides of the alkalies with organic materials necessarily means the more or less complete volatilization of the sulphur and chlorine, respectively, and the formation of the corresponding alkali carbonates, a point often overlooked in the consideration of ash analyses. As a consequence of these factors, the results obtained would certainly be misleading. It would appear, from the analyses of the ashes of the plants we are considering, that much more of these soluble mineral constituents can be leached from the plants than the plants ever contained, which is an obvious absurdity. For this reason it does not seem worth while to give these ash analyses any further consideration.

## SUAEDA INTERMEDIA AND ATRIPLEX BRACTEOSA.

TABLE XVIII.—*Suaeda intermedia.*

| | Sample IV—Stems. | | Sample V—Leaves. | |
|---|---|---|---|---|
| Grams of substance | 7.61 | | 14.35 | |
| Cubic centimeters of leachings | 750 | | 750 | |
| Percentage (mineral matter) leached out | 14.73 | | 23.80 | |
| Cubic centimeters N/20 acid, equivalent to 1 gram substance | .84 | | 2.67 | |
| | Percentage distribution. | Percentage in air-dried substance. | Percentage distribution. | Percentage in air-dried substance. |
| Ca | 0.48 | 0.071 | 0.15 | 0.036 |
| Mg | .75 | .111 | .72 | .170 |
| Na | 42.36 | 6.239 | 56.18 | 13.375 |
| K | 7.20 | 1.060 | 4.52 | 1.075 |
| $SO_4$ | 1.43 | .211 | .87 | .206 |
| Cl | 47.78 | 7.038 | 37.56 | 8.938 |
| | 100.00 | 14.730 | 100.00 | 23.800 |
| $CaSO_4$ | 1.62 | .239 | .51 | .121 |
| $CaCl_2$ | .00 | .000 | .00 | .000 |
| $MgCl_2$ | 2.66 | .392 | 2.35 | .559 |
| $MgSO_4$ | .35 | .057 | .64 | .152 |
| KCl | 13.71 | 2.015 | 8.61 | 2.049 |
| NaCl | 64.84 | 9.551 | 52.33 | 12.456 |
| Na | 16.82 | 2.476 | 35.56 | 8.463 |
| | 100.00 | 14.730 | 100.00 | 23.800 |

TABLE XIX.—*Atriplex bracteosa.*

| | Sample VI—Stems. | | Sample VII—Leaves. | |
|---|---|---|---|---|
| Grams of substance | 21.49 | | 17.79 | |
| Cubic centimeters of leachings | 750 | | 750 | |
| Percentage (mineral matter) leached out | 4.48 | | 10.24 | |
| Cubic centimeters N/20 acid, equivalent to 1 gram substance | 1.19 | | 3.61 | |
| | Percentage distribution. | Percentage in air-dried substance. | Percentage distribution. | Percentage in air-dried substance. |
| Ca | 2.32 | 0.104 | 0.39 | 0.040 |
| Mg | 2.05 | .092 | 3.36 | .344 |
| Na | 37.79 | 1.693 | 41.30 | 4.229 |
| K | 7.90 | .354 | 5.39 | .552 |
| $SO_4$ | 4.10 | .184 | 6.60 | .676 |
| Cl | 45.84 | 2.053 | 42.96 | 4.399 |
| | 100.00 | 4.480 | 100.00 | 10.240 |
| $CaSO_4$ | 5.80 | .260 | 1.33 | .136 |
| $CaCl_2$ | 1.74 | .078 | .00 | .000 |
| $MgCl_2$ | 8.03 | .360 | 7.57 | .775 |
| $MgSO_4$ | .00 | .000 | 7.08 | .725 |
| KCl | 15.03 | .673 | 10.27 | 1.052 |
| NaCl | 52.18 | 2.338 | 53.56 | 5.485 |
| Na | 17.22 | .771 | 20.19 | 2.067 |
| | 100.00 | 4.480 | 100.00 | 10.240 |

In Tables XVIII and XIX are found the data obtained from an examination of the *Suaeda intermedia* and *Atriplex bracteosa*, respec-

tively. For the purposes of this paper they may very well be discussed together. Both analyses show the production by the plants of an organic acid or acids strong enough to decompose alkali carbonates; and that to some extent salts of this acid or acids, as well as the acids themselves, accumulate on the plants. In both plants this acid organic material is accumulated on the leaves rather than the stems, a situation which would seem more favorable for its being brought into contact with the alkali carbonates on the surface of the ground.

The accumulation of considerable amounts of potassium is again a noteworthy feature with these species. In both cases there is an apparently greater proportion of potassium in the water-soluble portions of the stems than in the leaves, when considered in relation to the other elements present; but when considered in relation with the air-dried material as a whole, the amount of potash is about the same in both leaves and stems for each of these plants.

In the case of the stems of *Atriplex bracteosa* the conventional statement of the analytical results as salts would indicate the presence of calcium chloride as such, and on the stems and leaves of both the *Suaeda intermedia* and *Atriplex bracteosa* considerable amounts of magnesium chloride are indicated. That these salts were actually present as such, however, is negatived by the fact that the air-dried samples did not in any case show the presence of any notably deliquescent substance on their respective surfaces after being dried in the oven. The conventional method of statement is again misleading, as in the case of the *Distichlis spicata*, discussed above.

## SUMMARY.

From the facts which have been presented in this paper the following conclusions seem justified:[1]

1. That the plant species here considered can make a satisfactory growth on soils containing relatively large amounts of soluble carbonates.

2. That this satisfactory growth is probably due, in large measure at least, to the production and exudation by these plants of considerable amounts of soluble organic acids capable of decomposing soluble carbonates, and thus protecting the root crowns from the corrosive action of hydrolized alkalies.

3. That it appears certain that large quantities of the most valuable plant foods are removed from the soil by these plants, and that in any contemplated use of them, involving their cropping or removal from the soil, this factor merits earnest consideration.

[1] Acknowledgment is due Mr. Atherton Seidell for assistance in making the analyses presented in this paper.

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ARGENTINA: PROVINCES, RIVERS, RAILWAYS AND PRINCIPAL CITIES.

U. S. DEPARTMENT OF AGRICULTURE.

Report No. 75.

# INDIAN CORN IN ARGENTINA:

## PRODUCTION AND EXPORT.

BY

FRANK W. BICKNELL,
SPECIAL AGENT.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1903.

## ARGENTINE TERMS, WEIGHTS, AND MEASURES USED IN THIS BULLETIN.

METRIC SYSTEM.—The metric system of weights and measures is used exclusively in Argentina, except that certain local terms are still somewhat in use, but not officially.

MONEY.—Unless otherwise stated, expressions of value used herein have been converted into United States money. The Argentine gold dollar, or peso, is worth 96.5 cents in United States money. The Argentine paper dollar, in common use, is worth about 44 cents.

KILO.—The short word for kilogram, the metric weight equal to 2.2046 pounds avoirdupois.

HECTOLITER.—A metric measure of capacity equal to 3.531 cubic feet, or 2.8377 bushels, or one-tenth of a cubic meter. It is the standard used to express the specific weights, and thereby the quality, of grain.

TON.—The metric ton is equal to 2,204.6 pounds avoirdupois, or 39.36 bushels of shelled corn.

QUINTAL.—100 kilos, or 220.46 pounds.

METER.—39.37 inches.

KILOMETER.—0.621 mile.

HECTARE.—2.471 acres.

SQUARE.—4.17 acres.

LEAGUE.—6,672 acres.

CHACRA.—A farm devoted exclusively to agriculture.

CHACARERO.—A man who works a farm to raise crops.

ESTANCIA.—A stock ranch.

ESTANCIERO.—A man who owns an estancia, and generally the one who operates it.

PATRON.—The proprietor, the owner of the land rented to "colonists;" the employer of labor, or the head of the establishment on any kind of a farm.

COLONIST.—A renter of land for agricultural purposes, usually a foreigner, hence the term.

CAMP.—The term generally applied to the country, derived from the Spanish word "campo," meaning country. It has another meaning, applied to the land or pastures. A man will say, for instance: "My camp is in good condition."

TROJA.—Corresponds to our corn crib. It is made by setting strong poles in the ground and weaving canes and corn stalks through them to make a circular crib, to hold corn in the ear. Being loosely made, air can pass through the corn. Sometimes it is covered, but more often not.

CANALETAS.—Chutes, made in sections and hung on wire cables stretched from warehouses on the high banks of the Parana River to the ships lying in the stream below. Ships drawing 26 feet of water could be loaded in Rosario and other ports in this manner at trifling expense, but they can not load to more than 18 feet, as a rule, because of the bars in the river below. Besides the temporary canaletas, on cables, permanent chutes for the same purpose are also built on the banks all along the river. Bags of grain, yerba, or flour, bales of hay, tobacco, dried meat, and other cargo slide into the ships in this manner at small cost. This economical method will all be done away with in Rosario when the new port is built, hence shippers are planning to go elsewhere.

# LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
*Washington, D. C., November 25, 1903.*

SIR: I have the honor to submit herewith a report upon the production of Indian corn in Argentina and its exportation from that country. The investigation from which this report comes originated in some inquiries addressed to me in December, 1901, by Mr. Frank H. Hitchcock, then Chief of the Division of Foreign Markets of this Department. It was found profitable and necessary to a full understanding of the subject to enlarge the investigation so as to include the methods of production as well as the manner of exportation. The climate of Argentina also is a subject of interest in this inquiry, and a careful statement of climatic conditions, with comparisons with the United States, is presented. Two weather maps, one showing the annual isothermal lines and the other the distribution of rainfall, will serve to illustrate the statement.

The map of the corn district of Argentina accompanying this report gives the railway lines and rivers by which the surplus corn crop of the country is moved for export.

The information here presented will, I believe, be useful to many farmers and business men, and I suggest that it be printed as one of the reports of this Department.

Acknowledgment should be made for generous and valuable cooperation of officials, grain men, and farmers in Argentina in the prosecution of this inquiry. Among the many who were of assistance, special acknowledgment and thanks are due to Señor Don Ronaldo Tidblom, director of agriculture and animal industry; Mr. Russell Smith, inspector of hay, etc., for the British Government, now at the head of the commercial grain and hay inspection service for export from Rosario, Buenos Ayres, Bahia Blanca, and other places; Mr. J. Collett-Mason, estanciero of San Jose de la Esquina, Province of Santa Fe; Señor Eduardo E. Brett, Pehuajo; Mr. W. S. Martin, Rosario; Mr. W. G. Davis, director of the national weather bureau, and Mr. H. B. Coffin, Carcaraña.

Respectfully,

FRANK W. BICKNELL,
*Special Agent and Agricultural Explorer.*

Hon. JAMES WILSON,
*Secretary.*

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# INDIAN CORN IN ARGENTINA: PRODUCTION AND EXPORT.

## INTRODUCTION.

[For Argentine terms, weights, measures, etc., see back of title page.]

The methods, or lack of methods, in growing and harvesting Indian corn in Argentina have a great influence on the success of the exporting business. All these differ widely from our own methods, even more than Argentine corn differs from ours. But progress is to be expected in Argentine corn growing, which is now a separate occupation, not usually carried on by one man in connection with other crops. More and better home use is likely soon to be made of the corn they produce there, and instead of sending the greater part of the increasing crop out of the country, Argentina will in the near future use much of its surplus corn to fatten cattle and hogs for domestic consumption and for export.

### THE CORN AREA OF ARGENTINA.

In 1902 the area reported planted in corn in the entire Argentine Republic was 4,433,686 acres, but of this 3,963,897 acres were in the four provinces of Buenos Aires, Santa Fe, Cordoba, and Entre Rios, chiefly in the first two named. (See Pl. I.) The area within which corn is now grown successfully and as a serious business is roughly bounded by a line drawn around points distant from the city of Buenos Aires about as follows: To the south 225 miles and to the west 250 miles, all in the Province of Buenos Aires; to the northwest 325 to 350 miles, into the Provinces of Santa Fe, and Cordoba, and to the north 350 miles, into the Province of Entre Rios. Still, a great majority of the best corn is grown within a much smaller area than this—within 75 to 150 miles of the Parana River and within the same distance of either Buenos Aires or Rosario, the chief corn markets.

Outside the corn district just outlined, for 100 miles or more to the south, west, and north, corn is raised and will be raised in increasing quantities every year. Many parts of the great Territories of the Pampa and Neuquen, to the southwest, and of the Province of San Luis, to the west, are showing unexpected agricultural value. Land in San Luis and northern Pampa has had a tremendous boom during the past year, being wanted chiefly for alfalfa pastures on which to fatten cattle.

The cultivation of corn is a settled business in only a few localities where the greatest yields are secured. Otherwise it is unsteady and uncertain, depending upon the whims of large landowners who may decide to "colonize their camp with maize"—that is, plow up the pastures and put the land into corn, or turn out the wheat raisers and bring in corn raisers.

Wheat growing is going south, leaving the Province of Santa Fe, where it was first introduced, and is being succeeded by alfalfa, corn, and stock raising. This is extending more and more to the north, where colonists have been slow to believe they could grow corn successfully. One obstacle in the way of the country's development is that the farmers or "colonists" are not progressive, being mostly very illiterate persons, who never did any farming before they came to Argentina. They do not read and are very slow to make any experiments or adopt anything new. So it is not always easy to get colonists who have had any experience in corn raising to put in the first crop. Very low rents and favorable conditions are offered at first to get colonists to show what can be done with the land. In other words, corn raising in Argentina is still in the experimental stage, with its possible extent and importance very imperfectly realized.

Most of the corn grown in Argentina is raised north of latitude 36 south and largely in latitudes 35 to 33 south, while the corn belt of the United States is in latitudes 38 to 42 north—that is, the best cultivated corn region of Argentina ends now at a point more than 100 miles nearer the equator than that of the United States begins. There are, to be sure, marked climatic differences in the corn regions of the two countries.[a] Most of the temperate zone in Argentina south of latitude 36 south is considered too dry for corn, but this claim is not well established. Superior wheat is grown there, and already it has been found that in some parts at least corn makes a good showing.

With the present prospect that Argentines will soon begin to feed corn to cattle, that they will have hogs to fatten in the same way, and that the methods of corn production will improve, it is reasonable to expect that the production of corn will continue to increase very rapidly in Argentina. The profits of corn raising are sufficient, as the conditions and markets now are, to satisfy the man who works and plans as he should. If the additional inducements of profit from feeding and the good results of better culture are made clear to him, he may be confidently expected to take advantage of the rich opportunities presented by the fertile soil of Argentina. The exportation will, after a few years, not increase in proportion to the increased production. Feeding may be expected to consume an increasing quantity.

[a] See p. 10, under heading "Climate of Argentina."

PROSPECTIVE INCREASE OF SMALL FARMS.

Hardly any one thing has interfered more with the development of the Argentine Republic than the fact that most of the good land has been parceled out to a few favorites, at various times, in immense tracts. Until recently it has been difficult for a poor man to get a small tract of land for his actual use and occupation. He could rent, but he could not own. This is gradually changing, though a vast portion of the country is still owned in large blocks by men who are doing nothing to develop it and will not sell at reasonable prices to those who will. The land pays them handsome incomes for grazing and they prefer to hold it for higher prices. But as the country grows older families and estates divide more than formerly. Many colonies have been established and some of the big land companies and farming companies are selling off their land in small parcels. This is being done with the great Curamalan property of 300 leagues, or over 2,000,000 acres, owned by an English company which secured the land thirty or forty years ago from the Government at a very low price under an agreement to stock and operate it.

Mixed farming, as practiced in the United States, is almost unknown. But the country is developing in that direction as land increases in value. It is generally stated and believed that small owners are gradually becoming more numerous, as sales of lands and other evidences, especially systematic colonizing, indicate it. It is not supported by published statistics, however.[a] The need and benefit of having farmers who own their land, propose staying in one place permanently, and have an interest in the country is being better understood every year.

[a] Statistics published each year by the Argentine Department of Agriculture give the number of cereal farmers classified as to renters and owners. The information upon which these statistics are based comes from the thrashing-machine operators, and is no doubt incomplete and only approximately accurate. It probably has not included anything like all the corn raisers, but it is suggestive of the relative numbers of renters and owners. Condensed and compared with the farm statistics of the United States Census of 1900, these statistics show for four years as follows:

| | 1898–99. | 1899–1900. | 1900–1901. | 1901–02. | U. S. Census, 1900. |
|---|---|---|---|---|---|
| Owners | 13,415 | 15,013 | 13,815 | 13,060 | 3,713,371 |
| Cash renters | 15,690 | 14,290 | 14,715 | 18,819 | 752,920 |
| Share renters | 6,284 | 5,100 | 5,537 | 5,465 | 1,273,366 |
| Total farms reported | 35,389 | 34,403 | 34,067 | 37,344 | 5,739,657 |
| Percentage of owners | 37.91 | 43.64 | 40.55 | 34.97 | 64.69 |

The statistics for 1901–02 are not quite complete, having been published before the last of the reports had been received, so the number for that year should be slightly increased.

### IMMIGRATION.

The Government is very willing to encourage and assist immigration and colonization, in many practical ways. Owing to causes which they are now trying to study out, immigration has fallen off during the past year or two, and often the monthly balance is against the country—more going out than coming in. Many reasons are assigned for this condition of affairs. Complaint is made that the administration of justice is not what it should be, especially in the country, and that a poor foreigner has not much chance; that he is likely also to be burdened with oppressive taxes. Many Italians come to the country to work a few months, in the harvest, and then go home or to North America. The great prosperity and industrial activity in the United States has also had much to do with diverting European immigration from Argentina to this country. Immigrants are learning that Argentina is a poor place for a man without some capital, unless he is willing to live on very little at first and undergo many hardships. The country is, nevertheless, giving opportunity to Russians, Armenians, Boers, and drought-stricken Australians, all of whom are bettering their condition by engaging in agriculture.

## CLIMATE OF ARGENTINA.

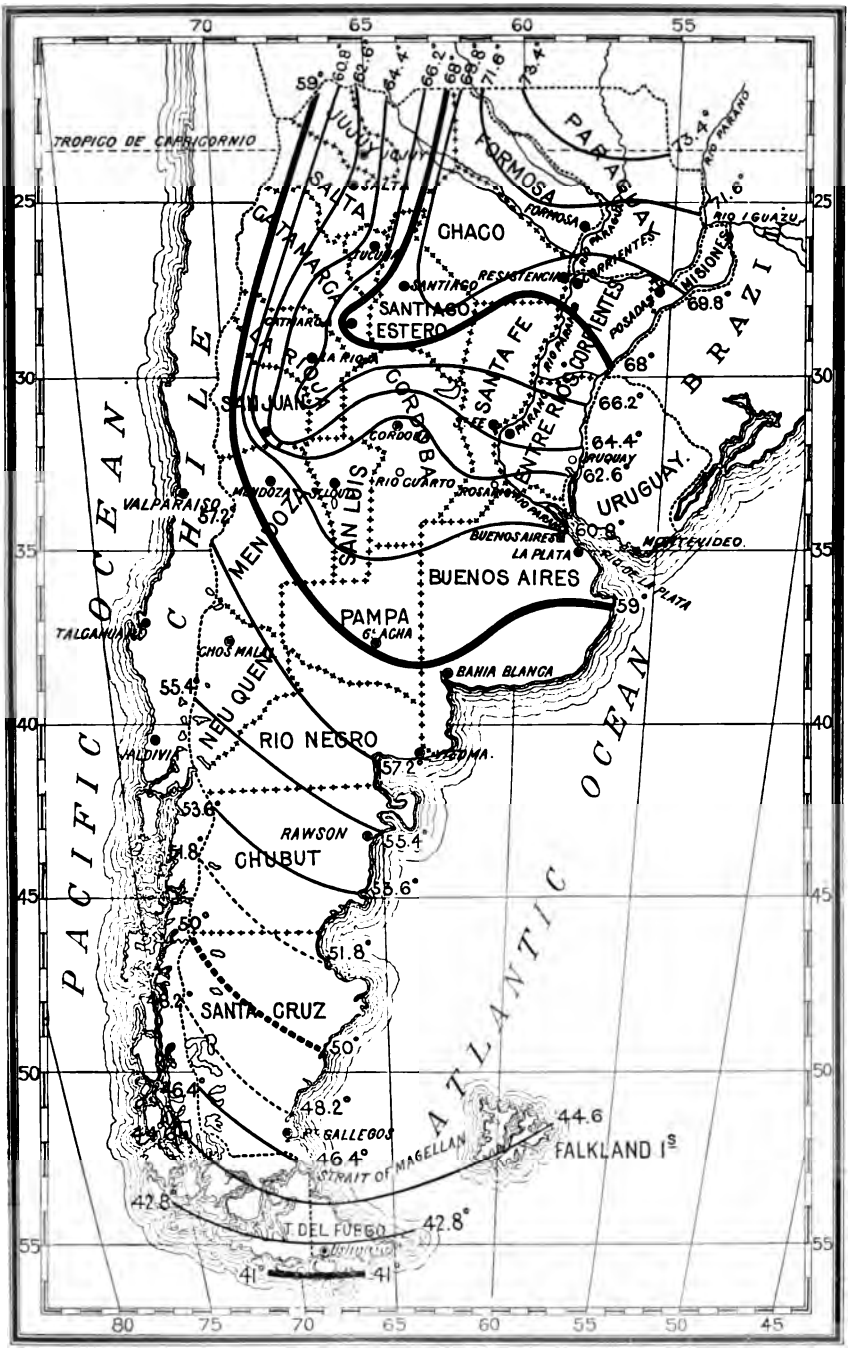
"What is the climate of the country?" is a question often asked about Argentina. Almost any desired climate, from tropical to frigid, may be had in a country that extends through more than 34 degrees of latitude, or more than 2,300 miles, from latitude 22 to 56 south, and is in places 800 miles wide. (See Pls. I and II.) Conditions vary widely in the same latitude. Rainfall diminishes from the east to the west until the very base of the Andes is reached. (See Pl. III.) Temperature is highest in the central part of the country, falling rapidly in the Andean region to a point many degrees below the temperature of localities due east, in the Litoral, which is the name given to the region including the Territories of Formosa, the Chaco, and Misiones, and the Provinces of Corrientes, Entre Rios, Santa Fe, and Buenos Aires, the best part of the country.

The second climatic division of Argentina is known as the Mediterranean region, embracing the central part of the Republic, from the Bolivian frontier on the north to the southern extremity of the continent, and the Atlantic coast to the south of the Province of Buenos Aires.

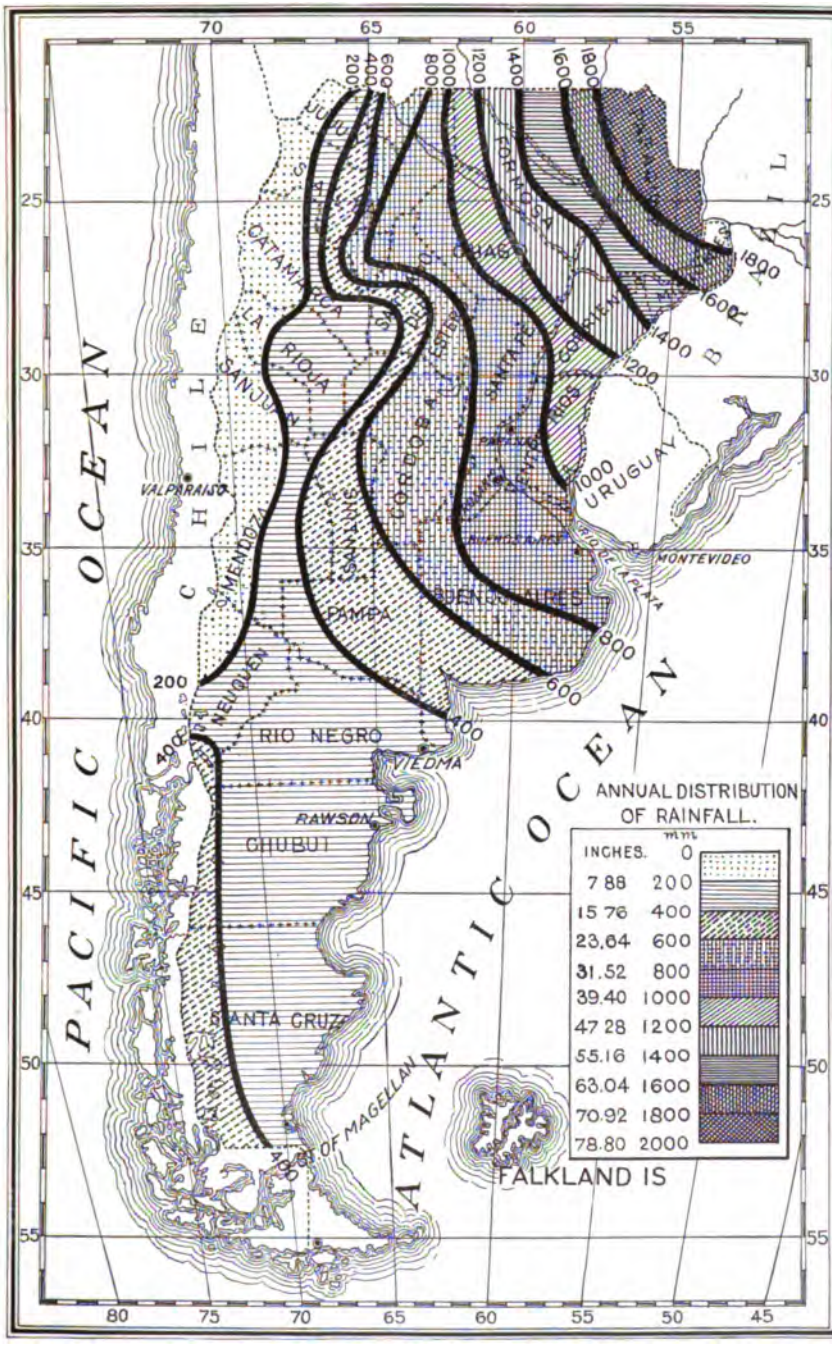
The third division is called the Andean, and comprises the region west of the Mediterranean and includes the eastern slopes of the Andes.

The highest recorded temperature,[a] 120°, was during the hot wave

[a] The centigrade thermometer is used in Argentina, but all expressions of temperature in this bulletin have been converted into Fahrenheit.




ISOTHERMAL LINES, SHOWING ANNUAL AVERAGES OF TEMPERATURE IN ARGENTINA.




RAINFALL IN ARGENTINA, ANNUAL DISTRIBUTION, VARIOUS REGIONS.

in February 1900, in the Province of Catamarca at the extreme north, and the lowest recorded temperature was 3°, in the southern extremity of the continent, a range of 117° of temperature in 33 degrees of latitude. The Argentina weather bureau states, however, that lower temperatures are probably experienced in the interior of the Territory of Santa Cruz. In the northern part of the Litoral the ordinary range of temperature is from 41° to 106° and in the southern section of the Litoral the usual limits are from 32° to 102°. This is the Territory in which most of the corn is raised, and the summer temperature averages from 72° to 77° and is rarely above 96°.[a]

A very good system of weather reports has been organized by the Argentine Government under the direction of Mr. Walter G. Davis, formerly a resident of Vermont, who has been in this service in Argentina for the past twenty-six years. The national telegraph service, which is part of the postal system, carries the reports, and the operators, in many cases, are observers. The best instruments have been supplied to observers and the national telegraph lines have been extended well over the country, so that now observations are reported and the conditions are being studied in the remotest sections. In the hands of the capable director the service is well organized and efficient. Weather maps similar to those issued in this country, are published daily by the Weather Bureau in Buenos Aires.[b] The temperature of the various parts of the country is shown by the isothermal lines as follows:

SUMMER.

The summer isotherm[c] of 77° starts on the Uruguay River in about latitude 31 south, runs through the upper edge of the Province of Entre Rios, through central Santa Fe, and downward to the city of Cordoba, where it dips south to the lower part of San Luis and Mendoza, and from there turns upward along the lower slopes of the Andes to Bolivia.

The summer isotherm of 75° begins at about latitude 33 south, runs west across the lower part of the Province of Entre Rios; thence southwesterly through the city of Rosario, across the southern edge of Cordoba and San Luis, the northwestern corner of the Pampa, and then

[a] The average annual temperature of the corn belt of the United States is about 50°. The season averages in Iowa are: Winter, 20.9°; spring, 47.3°; summer, 72.3°; autumn, 50.1°. The corn belt lies between the isothermal lines of 45° and 55°, annual.

[b] These maps have only been published a little over a year, and the service is not entirely perfected in the more distant parts of the country.

[c] The temperatures used to form the isothermal lines have been reduced to the level of the sea at the rate of 1° Centigrade to each 200 meters of altitude, or 1.8° Fahrenheit for each 656 feet. The corn region is scarcely affected by this operation, since it is nearly all less than 200 feet above sea level.

up through Mendoza, San Juan, La Rioja, Catamarca, and Salta to Bolivia.

The isotherm of 73° begins in about latitude 33.5 south and crosses the northern part of the Province of Buenos Aires, takes a southwesterly course through the central part of the Territory of the Pampa, and makes a curve from the central part of the Territory of Neuquen upward to about latitude 35 south.

The line of 72° starts at Buenos Aires, latitude 35 south, and follows a general southerly direction across the Province of Buenos Aires, the southwestern corner of the Pampa, the northwestern corner of Rio Negro and central Neuquen to the Andes.

The line of 70° starts at the seacoast in latitude 37 south, runs southwest along the coast to latitude 40 south, whence it crosses the Territory of Rio Negro, dipping a little to the south, and up a trifle north of latitude 40 south in Neuquen.

Autumn temperatures average in the temperate zone about 11 degrees cooler than summer.

WINTER.

The winter isotherm of 70° runs from the southeast corner of the Territory of Misiones, in latitude 27 south, to lower Catamarca, in almost a straight line, thence north to Bolivia.

The line of 57°, beginning in latitude 30.5 south, crosses lower Corrientes, central Santa Fe, northern Cordoba, south to the city of San Juan, and north to Bolivia.

The line of 55°, beginning in latitude 31 south, runs across Entre Rios to the city of Santa Fe, a little north to the city of Cordoba, southwest to the city of San Luis, through Mendoza northwesterly, and north to Bolivia.

The isotherms of 54° and 52°, beginning in latitudes 32 and 33.5 south, respectively, are nearly parallel with line 55°.

The isotherm of 50° begins at about latitude 34.5 south, a few miles north of the city of Buenos Aires, runs northwest to the middle of the lower point of Santa Fe, thence southwesterly along the borders of Buenos Aires, the Pampa, Cordoba, and San Luis, and upward through Mendoza to about the same latitude as that of the starting point.

The isotherm of 48° starts on the coast at about latitude 35.5 south and dips downward through the Province of Buenos Aires to a point about 50 miles north of Bahia Blanca, where it crosses the Pampa and Neuquen on a slight upward incline, ending in a sharp upward turn to latitude 37 south.

Below this the lines are more nearly east and west, both summer and winter. At latitude 39.4 south the winter temperature is 46.4°. At latitude 44 south it is 43°.

The spring temperatures average about 11° to 12° warmer than the winter temperatures.

### ANNUAL AVERAGE TEMPERATURE.

The highest annual average is 75°. This is in the northern part of Formosa and Jujuy, near the Tropic of Capricorn. At every 70 to 150 miles south the temperature is about 2 degrees cooler. The line of 66°, annual average, runs straight across the northern part of Entre Rios, central Santa Fe, and downward to the cities of Cordoba and San Luis, curves downward 50 miles south of the city of Mendoza and up to a point on the boundary due west of the last-named city. The isotherm of 63° goes across lower Entre Rios, just south of the city of Rosario and due southwest along the borders of Buenos Aires, Cordoba, San Luis, and the Pampa to Chos-Malal. At La Plata the isotherm of 61° begins and runs a little north to central northern Buenos Aires, where it bears off to the southwest, through the Pampa a little south of the center, into Neuquen. Bahia Blanca is in the line of 59° and from this point the lines are more nearly uniform, the temperature being about 2 degrees warmer on the Atlantic coast than at the base of the Andes. It averages about 2 degrees lower each 125 to 150 miles south until at the end of the continent, in about latitude 56 south, it is 41°.

The isothermal lines shown in the map given herewith (Pl. II) indicate average temperatures for the year from actual observations, not reduced to sea level. No temperatures taken in deep valleys or on high mountains have been considered, but only those that fairly represent the altitude of the region.

Observations of temperature have been made in the city of Buenos Aires since 1856. They are printed in three periods and the averages are, by seasons, as follows:

*Average temperatures at Buenos Aires.*

| Season. | 1856–75. | 1876–96. | 1897–1900. |
|---|---|---|---|
| | °F. | °F. | °F. |
| Summer (December, January, and February) | 74.3 | 72.5 | 75.3 |
| Autumn (March, April, and May) | 63.1 | 61.5 | 64 |
| Winter (June, July, and August) | 51.9 | 51 | 51.4 |
| Spring (September, October, and November) | 62.6 | 61.3 | 61.5 |
| Year | 62.9 | 61.5 | 63.1 |

These averages are not far from the averages of the principal corn regions, being but a trifle cooler than the northern part thereof.

### EFFECT OF HUMIDITY ON TEMPERATURE.

Though the temperature of the warmer part of the present best corn area, southern Entre Rios, Santa Fe and Cordoba and northern Buenos Aires, is not often above 96°, it seems 15 or 20 degrees hotter most of the time because of the high percentage of humidity. In the city

of Cordoba, the altitude of which is 1,000 to 1,200 feet higher than the farming country below, the average annual percentage of relative humidity is 64. In Buenos Aires and Rosario it is 78.[a] In the northern part of the Litoral, the Territories of Misiones, Formosa and the Chaco, and the Province of Corrientes, the relative humidity is 10 per cent greater. The report of the Argentine Weather Bureau contains the following concerning the effects of humidity:

It is not an uncommon occurrence in summer that the temperature of the air, during the hottest hours of the day, is considerably higher in the region of Chubut and Rio Negro than in Corrientes or the Chaco, 16 to 18 degrees nearer the equator. In the first-named region, however, one scarcely feels the heat; whereas, in the latter, the temperature is very oppressive. This is explained by the fact that the temperatures of the wet bulb thermometer are much lower in the southern territories, when these phenomena are observed, than those recorded in the northern region. In the city of Buenos Aires a temperature of 95° is very rare, while in Cordoba it is not exceptional in autumn and spring, and is frequently observed during the summer. In the first-named place this degree of heat causes a suspension of all labor that can be postponed, while in Cordoba it does not give the impression of being excessive, and work is carried on without inconvenience.

### WIND.

The effect of winds on temperature in Argentina is stated by Director Davis, of the Argentine Weather Bureau, as follows:

The north winds are hot, and the increase in the heat is, as a rule, proportional to the duration of the wind from this direction, while the south winds are cool, refreshing the air and relieving the suffocation produced during the successive days of north wind. In the Andine region the dry and hot winds are called zondas, which generally blow from north to northwest, and at times with such intensity that respiration is difficult. These winds rise about midday and last till sunset, but at times they last two or three days without interruption, being strongest in spring in the months of September and October. The changes of temperature after a severe zonda and the south wind which follows it are frequently as high as 45°. In the Litoral and Mediterranean the heat produced by the north wind generally terminates with a thunder storm or pampero. The pamperos in the Litoral are more frequent in winter and spring. The change of temperature caused by the two winds is frequently from 27° to 36°.

### RAINFALL.

The average annual rainfall in the corn district of Argentina is 31.52 to 39.40 inches, and it is quite evenly divided between the seasons.[b]

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[a] The average annual percentage of relative humidity in Iowa for the past 25 years has been 70 per cent, and for the crop-growing period, May 1 to September 1, it has been 69 per cent.

[b] The surplus corn States of the United States have an average of about 35 inches of rainfall, the range being from 27 inches in the northwestern part of the belt to 40 inches in the southeastern part. The average for Iowa is 31 inches for the whole State, of which amount 70 per cent falls in the six crop months, April 1 to October 1, and over 50 per cent in the four months, May 1 to September 1. By seasons, the State averages are: Winter, 3.32 inches; spring, 9.19 inches; summer, 12.02 inches, and autumn, 6.53 inches.

From October to March is called the wet season, and from April to September the dry season, in that part of Argentina north of latitude 38 south.

In Buenos Aires 56 per cent of the annual rainfall is in the wet season; in Corrientes 65 per cent of the rain falls in the wet season; in Cordoba 86 per cent, and in Salta 96 per cent. In the region south of latitude 38 south the distribution of rainfall is very even through the year. Snow falls every year in the Territories of Santa Cruz, Chubut, Rio Negro, and Neuquen, but it rarely reaches the Province of Buenos Aires.

The average annual rainfall in a number of representative localities is given herewith:

*Average annual rainfall in Argentine cities.*

| Station. | Latitude. | Longitude. | Years of observation. | Rainfall. |
|---|---|---|---|---|
| | ° ′ | ° ′ | | *Inches.* |
| Villa Formosa | 26 12 | 58 6 | 1879 to 1892 | 57.14 |
| Corrientes | 27 28 | 58 50 | 1876 to 1900 | 49.28 |
| San Lorenzo | 28 10 | 58 45 | 1892 to 1900 | 35.16 |
| Goya | 29 9 | 59 16 | 1876 to 1900 | 38.31 |
| Monte Caseros | 30 14 | 57 38 | 1893 to 1900 | 40.65 |
| Concordia | 31 23 | 58 4 | 1876 to 1878 and 1887 to 1898 | 42.05 |
| Parana | 31 44 | 60 31 | 1875 to 1882 and 1896 to 1898 | 35.45 |
| Uruguay | 30 30 | 58 13 | 1895 to 1899 | 45.49 |
| Carcarañia | 32 49 | 61 8 | 1889 to 1900 | 35.11 |
| Rosario | 32 57 | 60 38 | 1875 to 1880 and 1886 to 1900 | 37.46 |
| Buenos Aires | 34 37 | 58 22 | 1861 to 1900 | 36.76 |
| Estancia San Juan | 34 49 | 58 3 | 1867 to 1900 | 42.57 |
| Dolores | 36 18 | 57 40 | 1889 to 1900 | 32.32 |
| Maipu | 36 51 | 57 53 | 1888 to 1900 | 26.77 |
| Azul | 36 45 | 59 50 | 1888 to 1900 | 32.29 |
| Tandil | 37 17 | 59 8 | 1888 to 1900 | 32.47 |
| General La Madrid | 37 13 | 61 16 | 1888 to 1900 | 25.73 |
| Bahia Blanca | 38 45 | 62 11 | 1860 to 1883 and 1896 to 1900 | 20.58 |
| La Carlota | 37 10 | 63 50 | 1891 to 1900 | 21.53 |
| Rawson | 43 17 | 65 5 | 1880 to 1888 and 1896 to 1900 | 9.46 |
| Salta | 24 46 | 65 24 | 1873 to 1897 | 22.08 |
| Tucuman | 26 51 | 65 12 | 1873 to 1900 | 38.02 |
| Santiago del Estero | 27 48 | 64 16 | 1873 to 1890 | 19.57 |
| Cordoba | 31 25 | 64 12 | 1873 to 1900 | 27.48 |
| Rio Cuarto | 33 7 | 64 19 | 1881 to 1882 and 1900 | 26.46 |
| San Luis | 33 19 | 66 20 | 1874 to 1877 | 21.57 |
| Catamarca | 28 28 | 65 56 | 1881 to 1900 | 12.67 |
| La Rioja | 29 19 | 67 1 | 1875 to 1892 | 10.78 |
| San Juan | 31 32 | 68 31 | 1875 to 1900 | 2.93 |
| Mendoza | 32 53 | 68 49 | 1866 to 1880 and 1885 to 1900 | 7.08 |
| Chos-Malal | 37 27 | 69 49 | 1892 to 1896 | 7.52 |
| Ushuaia | 54 52 | 68 7 | 1876 to 1885 | 23.15 |
| Isla de los Estados | 54 23 | 63 47 | 1886 to 1893 and 1899 to 1900 | 54.06 |

The distribution of rainfall throughout the country is graphically shown by the chart (Pl. I), which was made by the Argentine Weather Bureau from observations at more than 150 stations well distributed over the country, covering periods from eight to twelve or more years at most of the stations. The observations in the interior of Formosa and the Chaco, and in the region at the foot of the Andes south of latitude 38 south, were not sufficient for a permanent record, but otherwise further observations may not be expected to show changes, says Director W. G. Davis in his report.

The records also show that the rainfall was well distributed through the months and the days of the months. Rain falls, on the average,

42.2 days per year in Corrientes, 39.2 days in Goya, 55.7 days in Concordia, 50.3 days in Parana, 59.2 in Buenos Aires, 82.2 days in Tandil, 53.5 in Bahia Blanca, 70.3 in Cordoba, 68 in Rio Cuarto, and 58.8 in San Luis.

## THE PRODUCTION OF CORN.

### EXISTING CONDITIONS AND METHODS, AND PROBABLE IMPROVEMENT.

The production of maize, or Indian corn, in the Argentine Republic, while it has been going on for many years, is only now developing into a great industry. It is just growing out of the primitive methods that have been holding it back and which still prevent farmers from realizing much more than half what they might. The results they achieve are due to the marvelous fertility of the soil and the perfect climatic conditions, which, in spite of bad methods, neglect, and general ignorance, give bountiful harvests to men who would utterly fail in the corn belt of the United States if they farmed as they do in Argentina; and these men can not long continue in this manner where they are. Their only natural disadvantage is that they are likely to get too much rain during the gathering season and they may have too little during the growing season; but where they have a range of about five months in which to plant corn and still be reasonably sure of a crop, much of the fear of insufficient rains during the plowing, planting, and growing seasons is taken away.

The methods of cultivation are improving every year, as the corn area extends and the leaven of modern ideas slowly penetrates to the slow-thinking colonist. He would progress much faster in the United States, because he would have the example of better farmers all around him, while in Argentina he sees nothing better than his own miserable efforts, and he is no theorist, to adopt new methods simply because some one has told him to do so. The chances are that he has never seen anything grow before he came to be a "chacarero" on some large place in the new southern country. Never having had any land to work before, never having had room enough to live or a chance to do anything on his own account, he becomes greedy when he sees so much land on which he is free to go, and wants to take far more than he can work well. Every colonist wants at least 100 hectares, equal to 247 acres, and sometimes he succeeds in getting more. This is, however, the usual limit for a family, unless there are several large boys. The rule on some large corn farms is that 25 squares, or about 104 acres, shall be allotted to every able-bodied working hand. Farming as they do, a man can work that amount of land in corn until the gathering is upon him, when he must have help or suffer heavy losses.

FIG. 1.—HUT OF ITALIAN "COLONISTS" IN ARGENTINA.

FIG. 2.—FIELD OF CORN IN ARGENTINA JUST BEGINNING TO TASSEL, ITALIAN COLONIST IN CENTER.

THE FARMER AND HIS HOME.

Most of these "colonists," or renters, are from the north of Italy, and are very industrious and thrifty. They work and live under conditions that would not be endured by the poorest farm hand in our country. Yet they have here a chance that they could not have at home, and most of them become well off in a few years. But a great many of them do not like the country, and are leaving it and returning to Italy or coming to the United States. The reason most commonly given is that they are oppressed by the petty local officers and made to pay excessive taxes and unjust fines. Some of them, however, become citizens and occupy positions of influence among their fellows. Others desire only to accumulate money to live comfortably in Europe. A better class of corn farmers are the Austrians, who are not numerous. They build frame houses and live far better than the Italians, and yet seem to make as much money. The Italian renter builds a mud house with a zinc roof, all the materials being furnished by the "patron," the owner of the land. Several hard-wood posts are set in the ground and small boards nailed across the top. The sheets of zinc are then spread over the frame for a roof, with a slight pitch. Wire is tied from post to post and cornstalks woven in, the wire holding them up. Mud is plastered on both sides of the stalks and soon dries. A hole is left for a door, and perhaps, but not always, a smaller hole for a window, and the house is done. I made a photograph of one of these dwellings, which was about 12 feet long and 8 feet wide (Pl. IV, fig. 1). Four men and a boy lived in it, and were doing a good business, cultivating something over 400 acres of corn. The head of this gang is the one shown in the picture (Pl. IV, fig. 2) standing in the corn, which at that time, December 22, was about eight weeks old.

LAND RENTING, INCLUDING TERMS, PRICES, ETC.

These men came to the land with nothing but their strong bodies as their capital. The big Italian standing in the corn was the boss and the responsible man, if anyone was responsible. The owner of the land had this contract with them: He gave them the land, material to build the house, plows, harrows, cultivators, planting machines, necessary mules and bullocks to work, and two horses to draw water and ride in caring for the other animals. He became responsible for their credit at the country store for an amount equal to about $12 of our money, per month and they fed themselves, paying the account at the store when they received their share of the proceeds of the crop. One-third of the cost of the seed, harvesting, and shelling was charged to the tenants. They agreed to work the land to the satisfaction of the owner, and for all this they received one-third the proceeds of the sale of the crop, the owner selling when he saw fit. It is on some such

terms as these that the poor man gets his start, and in a year or two he advances to the next stage, where he furnishes everything and delivers to the owner at his warehouse a share of the crop ranging from 16 to 22 per cent—16 per cent the first year, 18 per cent the second, third, and fourth years. Other contracts call for 20 per cent the first year, 21 the second year, and 22 the third and fourth years. This was in a comparatively new district, the advantages of which were not so well known. Higher rents are obtained elsewhere, nearer the Parana River, where the land is known to be very rich and the market is very near. The third step of the corn raiser is the payment of cash rent.

The cash-rent system is the one generally in vogue, though nearly every large "chacra," or farm devoted to agriculture, has all three plans in operation. The prices paid vary greatly, according to location and supposed fertility of the land and its adaptability to corn. The price on the place I am speaking of, which is located 70 miles west of Rosario, was from $5 to $9 per square, which is a fraction over 4 acres. The latter is now the ruling price and it will probably soon be advanced. The lower price was offered when the land was converted from wheat—which was a failure—to corn, to induce the better class of corn farmers from nearer the river to come out there and take the land. Now that its adaptability to corn is established, the owner will doubtless have no trouble to rent it to good men, as renters go in Argentina, for higher prices than he is now receiving. In the best corn lands, near the Parana River, rents have been paid as high as $4.25 an acre, but this is exceptional and above the average, even for the best lands. Half of this rent must be paid in advance and the colonist agrees to use all the land, except 4 per cent for his house, garden, corrals, etc., for corn or linseed; and only 10 per cent for linseed. He agrees to keep out all noxious weeds and he must plow and cross plow before planting, dropping the seed corn behind the plow the last time with a machine attached to the plow. Then he must follow with the harrow, and harrow again after the corn is up, and cultivate once with a single-shovel, one-horse cultivator. Hardly a farmer cultivates his corn more than once, and only one way, but many of them are required by their contracts to go through after cultivating and pull the worst of the weeds.

In other parts of the country, farther south, in the Province of Buenos Aires, rents for corn lands range from $1.50 to $2.50 per acre, depending upon how near the market and how good the land. While most of the corn is raised by renters, the number of small proprietors is slowly increasing.[a] The valuation generally put upon agricultural land is to call the rent 8 per cent of the value. But land can be bought cheaper than this if one knows where and how to go, especially in large tracts. The best farming land in the country has been selling at

[a] See footnote, p. 9.

FIG. 1.—CORN OF DIFFERENT AGES IN SAME FIELD IN THE PROVINCE OF SANTA FE.

FIG. 2.—PORT OF ROSARIO, ARGENTINA, LOWER LEVEL.

prices ranging from $6 to $15 an acre. A tract of 1,943 acres about 75 miles west of Rosario, in an excellent corn district, was sold for $13.75 per acre, $3,500 down and the balance in annual payments at 6 per cent interest. Land within 50 miles of Buenos Aires is worth three to four times as much as this.

### THE FARMER'S FOOD AND DRINK.

Formerly colonists were allowed as much as 12 per cent of the land allotted to them, rent free, for pasturage, corrals, house grounds, etc. Now they have to pay for it all, even the 4 per cent which they are allowed for such purposes. But it must not be supposed that the colonists want this land for gardens, for they very seldom have them. Rarely do they raise as much as a cabbage, living on bread and meat and a few potatoes, and perhaps a few other vegetables that they buy. They might have fine gardens, but they are intent on making the land produce all it will that is marketable. Comforts and luxuries are not included in their ideas of life in Argentina. They have two meals a day, at about 11 and 7, with little besides the "yerba maté," or Paraguayan tea, early in the morning. This wonderfully nourishing and muscle stimulating drink is sucked through a tube from a gourd that holds about 4 ounces of water. Boiling hot water is repeatedly poured over the tea leaves in this gourd, and one filling suffices for a dozen fillings of water. The same tube is used by everyone present, even when there is company. It is a very wholesome beverage, in use all over Argentina, and the common people are very much attached to it. Some of them put sugar with it, but it is more wholesome without, though it is quite bitter.

### LONG SEASON FOR PLANTING.

Planting of corn may begin as early as August 15, but generally not until three or four weeks later, and it may be as late as January 15, though generally it is not considered quite safe to plant later than December 20. (See Pl. V, fig. 1.) On the 18,000-acre place which I have referred to, at San Jose de la Esquina, some planting was done as late as January 12 this year and a fair crop secured. The early planted corn was ripe at the end of January, but harvesting was not commenced until the latter part of February. Three men came to this place at the end of August and plowed, cross-plowed, planted, and cultivated 400 acres themselves and had a good crop, averaging about 40 bushels to the acre. In adjoining fields may be seen corn in full tassel and corn just out of the ground. Of course the early corn generally has the best chance, because it then gets the full benefit of the hottest weather to mature and ripen. The latter part of the summer is likely to be rainy, and in damp seasons the plants grow to such a size and are so close together that the lower ears do not get sufficient

air or sunshine to ripen or dry out. This results in uneven dryness of ears in the same field. Corn of uneven ripeness is likely to cause trouble and, being deficient in starch and having its sugar imperfectly formed, is inferior in food value, besides being likely to heat and mold and spoil other better grain. The unripe condition of corn exported is not always discovered until it has been sent across the ocean and caused some losses on the voyage. Often late planting is due to drought in the spring, which prevents plowing. Disk plows from the United States are now being introduced to a considerable extent, both among corn farmers and wheat farmers, as they have been found of great value in dry seasons when the ordinary mold-board plows could not be used.

### GATHERING, CRIBBING, AND SHELLING.

Farmers are usually in a hurry to get their money and so are apt to gather their corn too soon and have it shelled too soon. Shippers are eager to get cargoes off while the weather is dry, and this stimulates premature marketing. It is in the harvest season that the Argentine farmer has his greatest trials. Almost invariably he has more than he can gather without extra help, and that is difficult to get. Often, to save time and realize on his crop sooner, he arranges to shell directly from the field, rushing his grain to market before it has had any chance to dry. When this is not done—and oftener it is not—the corn in the ear is put into a crib, called a "troja," which is a round receptacle made of poles stuck in the ground with wire and cornstalks woven in among them, making a sort of bin, not always covered. This being more or less open gives the air opportunity to circulate through and dry the corn, especially if the troja is thatched over. They serve the same purpose as our corncribs do. The corn is gathered into sacks in the field and carted to these deposits. It is never husked into a wagon box in the field, as in the United States. The sacks of ears, husked, weigh about 143 pounds, and the men are paid by the sack for husking Ordinarily the men are paid about 8 cents per sack and boarded, or 10 cents per sack and board themselves, but this year the demand for help has been so great, owing to the immense crop, that prices for husking have gone to about 11 cents per sack and board, up to as high as 16 cents per sack without board. A man will gather 8 or 10 bags per day. This year's crop is the largest the country has ever had and prices are very good—about 40 cents per bushel—but the farmers are suffering heavy losses because they have been unable to get men to work in the harvest. Even better prices than those quoted have been offered and the cities are full of idle men, and still the corn is rotting in the fields. These prices for labor may not seem high to a farmer in our country, but farm laborers in the Argentine Republic usually get about $13 a month and their board, which costs their

employers but a very small sum, not more than $4 a month at the most, and usually less. It is estimated that the cost of gathering, shelling, and bagging is about 13 cents per bushel.

Shelling is usually done alongside the trojas, which hold from 1,500 to 8,000 bushels of corn in the ear. Sometimes the corn is shelled at once, without any opportunity to dry, or it may remain in the troja several months. It has been found best by experience that the least possible time should elapse between the time of shelling and loading on shipboard, and the Argentine Department of Agriculture has so advised. "It is better to run the risk of some extra cartage during the winter when the roads are bad," says one man of wide experience, "than to let the grain become heated in bags when deposited in a warehouse." Nevertheless, farmers are more apt to shell their corn as soon as they can get a machine. In many instances the man who runs the machine also buys the grain on the spot, paying 19 to 35 cents per bushel shelled and making no charge for shelling or bagging. Prices for shelling range from 1½ to 2¼ cents per bushel. All corn, as well as wheat, is shipped to market in bags weighing in the neighborhood of 150 pounds. These are coarse burlap bags and are worth about 10 cents each.

### MISTAKE OF CLOSE PLANTING.

Aside from lack of cultivation, the principal mistake of the Argentine corn grower is his unwillingness to give his plants room enough to grow and get air and sunshine to mature and ripen. As previously stated, most of the corn is planted with a machine attached to the plow, and the rows are generally about 20 inches apart—simply drilled in, resembling very much a field of fodder corn in this country. A few of the farmers are learning better, and perhaps 100 American corn planters have been sold in Argentina. But no check rowers were seen, and there is so little cultivating corn two ways that it is still spoken of as a curious thing—this "North American checkerboard plan" of planting corn—and scarcely a farmer in the country follows that plan. The Basques, the most industrious and successful class of Spaniards, go in for better methods. The Catalans, from the Province of Catalonia, Spain, are also engaged in corn growing in the Province of Buenos Aires. In some sections, notably to the southwest of the city of Buenos Aires, where some of the best corn farming is done, it is noticeable that the better the farming, the more experienced and successful the farmers, the wider apart the rows are, and occasionally a field is cultivated both ways. The rows in the better cultivated sections are from 24 to 30 inches apart, and the plants in the rows about 20 to 24 inches apart. Corn is hardly ever planted farther apart than this, and the greater part, in fact nine-tenths, is in rows 20 to 22 inches apart, and the plants no farther apart in the rows and generally much closer together.

GOVERNMENT EFFORTS TO SECURE WIDE PLANTING.

The Argentine Department of Agriculture has tried to teach the farmers the benefits of planting farther apart, but they are hard to convince. Men have been sent around in various sections saying to farmers: "Give us a hectare of land and we will plant it and cultivate it the way we think it should be done; we will bear all the expense and you may have all the crop." These experiments have always resulted in producing twice as much, or more than twice as much, as the farmer raised alongside in the old way, because the corn was given plenty of room and was well cultivated. But the ignorant farmers have not always been convinced. When asked how they were going to plant next year, some of them said they intended to go on as before. When asked why, and if they had not seen the good results of the improved methods, they have replied: "Oh, that was just luck; you couldn't do it again." Until recently corn was simply sown broadcast, by hand, covered in some primitive fashion, and nothing more done with it until it was gathered in the fall. Even now much of this is being done in some parts, though not in the districts where corn grows best.

SURPRISING YIELDS.

It is surprising to a North American to see what yields result from such slovenly agriculture. The yields vary greatly in different sections under different treatment and because of varying soils or climatic conditions. There are no complete and reliable crop statistics, such as we have; but, from careful observation and inquiry and from the study of such statistics as are available, very close estimates may be made of the corn yield in various sections. In some places a yield of 25 bushels to the acre is considered fair; but these are outside the preferred corn area and do not represent the best cultivation, even of the Argentine farmer. On the other extreme we find on the rich alluvial lands between Buenos Aires and Rosario, not more than 70 miles back from the River Plate and the River Parana, and in the splendid new country to the west and southwest of Buenos Aires, where the best cultivation is done, the yields run up to 70, 90, and even as high as 110 bushels to the acre. But these are above the average for the average corn country. In the larger part or, say, three-fourths, of the area that may be considered corn country, fairly tested and farmed by the better class of farmers, the average crop is better than 40 bushels to the acre. In the better sections, say one-third of the entire preferred corn area, a conservative estimate would be 50 to 60 bushels to the acre, with many fields showing better results. But beyond the favored "coast district," as it is called, a section about 70 miles wide and perhaps 300 miles long, swerving inland to the west from Buenos Aires and reaching up beyond Rosario, they are learning that proper methods will produce almost, if not quite, as good results.

Places that have rented for 35 to 80 cents per acre and where 23 to 32 bushels an acre was considered very good with simply planting behind the plow, without any cultivation, have shown yields two and three times as great when properly planted and cultivated.

In the future corn production in Argentina is sure to be brought to correspond more nearly with the methods pursued in the United States.

### ARGENTINE CROP AND EXPORT IN RECENT YEARS.

At present considerably more than half the corn grown in the country is exported. The statistics prepared by the Argentine Department of Agriculture, the only statistics available, give the area planted in 1901 at 3,473,722 acres and the total yield of the country at 84,018,265 bushels, or an average of 24.18 bushels per acre. Of this crop the custom-house statistics show an exportation of 46,843,282 bushels. Owing to the system of preparing these statistics, this amount is probably slightly in excess of the amount actually exported, but only slightly. This crop was grown between September, 1901, and March, 1902, and 90 per cent of it was marketed between March and October, 1902.

The corn crop of the United States was short in 1901, so it is not fair to use the crop and exportation of that year for comparison. But in 1900 the area planted to corn in the United States was 83,320,872 acres. The total production was 2,105,102,516 bushels, and the average yield per acre was 25.3 bushels. The exportation that year (1900–1901), including corn meal, was 181,405,473 bushels, or 8.62 per cent of the total production, while the Argentine exportation in the calendar year 1902 was 55.75 per cent of the total production. Of course the shortage of the corn crop in the United States in 1901 stimulated prices and exportation from Argentina in 1902, but this is the general rule, that half, or more than half, of the Argentine corn crop is exported when there is a good crop.

In 1902 the State of Iowa alone had 9,302,688 acres of corn, against 3,473,722 acres in the entire Argentine Republic in 1901–02. While Argentina sent out of the country 55.75 per cent, or 46,843,282 bushels of her total production of 84,018,265 bushels, the State of Iowa kept in the county of its growth all but 32,745,462 bushels, or 11 per cent of the crop, which was 297,686,016 bushels. The comparison would be much stronger if we could know the amount of corn shipped away from the place where it was grown in Argentina, but not sent out of the country. It would be at least 80 per cent of the crop and probably more.

This year (1902–03) the acreage of the crop harvested from February to June in Argentina is reported at 4,433,686 acres and the yield, not yet fully reported, is known to be larger per acre than the previous year. Owing to many difficulties this crop has not been

coming to market as fast as it should, yet the shipments up to November 5, 1903, were more than 50 per cent greater than they were up to that time a year before. It is generally estimated by competent persons in Argentina that the exportation this year will be about 75 per cent more than last year.

But at present the production of corn in Argentina is an uncertain business, owing to the difficulties of the harvest and the marketing and to the fact that the value of the crop depends so largely upon conditions in other countries. For instance, the price in 1901 held up high until early in June, when, the reports from the United States being favorable, the price in Europe went down, until it was about the same as it is now, averaging around 40 to 42 cents per bushel for the best in the River Plate markets. Of course it is a good business at that price, and might be much better if the methods of cultivation and harvesting were improved.

### PROSPECTIVE INCREASE OF FEEDING CORN TO STOCK.

The most far-seeing Argentines realize that they must adopt the North American policy of sending corn to market on four legs, in the condensed form of beef and pork. One of the best known and most experienced of the farmers and stockmen of the western part of the Province of Buenos Aires, where some of the best corn is raised and a comparatively good class of farming is done, said:

> We have no reliable market for our corn. Europe at any time may take much or none. Brazil and the Cape are progressing too slowly to be of any consequence. We are all therefore extremely careful not to invest all we have in corn. Its future here depends entirely on our ability to provide home use for it. This we are starting to do. A few are planting corn to fatten export cattle and hogs. Most farmers cultivate roughly, one way only, with horse shovels. They have generally no idea of proper distance to plant or how to cultivate. For the most part the farmers are illiterate men who never did any farm work before coming to this country. Under such circumstances it is surprising to see how well they do get on. They are chiefly Spaniards (from the province of Catalonia) and of late years more Italians. They obtain from 40 to 70 bushels to the acre and in the vicinity of Chacabuco (127 miles west of the city of Buenos Aires) 90 bushels to the acre was quite common last year. Rent varies from $1.60 an acre outside, say 70 miles from the river, to $2.25 an acre inside. Most of the land is rented, but small proprietors are fast increasing, hence the manner of cultivating is rapidly increasing. This is shown by the increasing amount of improved machinery and implements sold. I think the fact that a large amount of the corn exported is used for distilling accounts in part for carelessness in shipping.

A general opinion was found to prevail among the better class of "estancieros" that they must grow and feed corn. One man offered extremely liberal terms to secure some North American corn raisers to come down and use some of his land, well suited for corn, to show how the crop should be grown. These men differ from the common farmers, or "colonists;" they are quick to take up new methods when they become convinced that they can make money by doing so. Once

they get started into anything they go into it heavily, as they have into alfalfa. As soon as they fully realize, as some of them now do, that corn is the other thing they need to supplement alfalfa in the production of beef, we shall see them going in for corn, and raising it themselves on their large stock ranches, to finish their cattle. If the English ports are again opened to Argentine live stock, as Argentines hope, it will hasten the development of corn production; for those who are well informed in regard to the cattle trade in England know that the Argentine stockmen can never compete with the corn-fed steers from the United States until they also finish their steers for at least six months on corn. As long as they have only the "frigoríficos" (frozen or chilled meat houses) in Argentina for a market, they will not be in so much haste to begin corn feeding, because for that market, especially for frozen beef, it does not make so much difference. They claim it would not pay to feed corn at present, and it is very seldom done, except for show purposes or some other special reason.

### USE OF CORNSTALKS.

Very little use is made of cornstalks in Argentina at present. Usually they are plowed under as soon as possible. Some of the more painstaking farmers gather them into windrows, when dry, and burn them. Scarcely any corn is cut for fodder, nor are cattle turned into the fields after husking to any great extent. Green feed is usually obtained in the pastures all winter. Feeding the stalks, at least in the field, is being looked upon with more favor in the more progressive regions, and in time the corn-harvesting machinery of the United States will be employed in making use of the stalks to the best advantage.

### VARIETIES OF CORN GROWN IN ARGENTINA.

Although eight varieties of corn were recognized by the Argentine Rural Society in its catalogue for the agricultural show in May, 1903, only four or perhaps five kinds are recognized commercially. They are here described.

### KINDS IMPORTANT IN COMMERCE.

*Yellow.*—This is the common kind which forms 90 to 95 per cent of the crop and is practically the only kind recognized in European markets. This is a small kerneled, long and slender eared sort, very much the same as our flint corn. The kernels are very hard and smooth, but it is a very heavy, rich, strong grain and it does not absorb moisture as the softer-grained varieties do; hence it stands a long ocean voyage better. It is highly valued for distilling and for fattening. For the latter purpose it is usually partly crushed, as it is so hard that animals do not masticate it readily. The plant is very sturdy and prolific, usually bearing two or three ears.

Yellow corn goes by various names, the most significant being

"Cuarenton" and "Cincuentino," from the Spanish words "cuarenta," meaning forty, and "cincuenta," meaning fifty. The name is applied signifying the number of days required to begin the formation of ears.

*Morocho.*—This is a white corn, otherwise somewhat similar to the yellow—small, smooth, and flat. It is preferred for horses, as it is said to be strengthening without being fattening. It is not equal to the yellow corn for distilling.

*Polenta.*—Polenta is a Piedmontese variety, which originally is small and red, with a smooth, flat grain. It is used to make meal for table use, especially for a sort of mush, of which the Italians are very fond, and from this it gets its name, the Spanish word "polenta," meaning corn-meal mush. After a few crops this variety degenerates into ordinary yellow corn and fresh seed must be imported. It is seen in all degrees of purity and its cultivation is increasing.

*Pisingallo.*—This is a small-kerneled, small-eared, white-flint, chiefly from tropical regions. A very good quality, but little grown.

*Criolla.*—"Maize criolla," or native corn, is an inferior variety, grown in the northern part of the country, in the provinces of Cordoba, Santa Fe, Corrientes, and Entre Rios. It is yellow, smaller than the other varieties, smooth, and very hard. It is too hard for horses and is of little value for distilling. It yields poorly, has an extraordinary amount of husk and stalk, and ripens slowly. Its chief recommendation is that it is immune from the attacks of locusts, unless they get it in tassel, fresh. It is often sown in case of failure of some other crop, as sometimes happens with corn of other varieties. It is sown as late as the 1st of December and requires sixty days to form ears. The corn brings a poor price in the market and but little of it is offered.

### NORTH AMERICAN VARIETIES IN ARGENTINA.

Some of the large North American corn, both white and yellow, commonly called "horse tooth" corn, has been tried in Argentina, but it is not yet popular. They think it is not as strong as the flint varieties they have been raising, and no doubt it will not do as well when crowded as they plant it. It is claimed that our dent corn degenerates in Argentina. But some farmers have a desire to try our varieties and our system, and they will soon get into it. Recent experiments, especially the one by Dr. F. R. Cibils, the well-known Argentine agricultural writer, chief of the Division of Commerce and Industries of the Argentine Department of Agriculture, have shown the adaptability and value of North American varieties in Argentina.

### GOVERNMENT EXPERIMENTS ON VARIETIES.

An experiment was made during the season of 1901–2 with twelve varieties of corn, six of them North American, near Pehuajo, 225 miles west of the city of Buenos Aires, on the Western Railway. The results were not as satisfactory as expected, owing, it is said, not so much to

the lack of adaptability of the varieties as to the unfavorable weather of the season. The unusually heavy rains of October and November prevented the plants from getting a good start, and at the end of December they were injured by withering heat. Yet some good results were secured, to be the basis of future experiments. It was demonstrated that the large North American dent corn will give splendid results in Argentina if rightly cultivated in seasons not unfavorable to corn growing.

### TABULATED RESULTS.

The seed for this experiment was sent out by the Division of Agronomy of the Argentine Department of Agriculture, after having been carefully tested by that division, which made a report on the seed from which the following information was taken. The country from which the seed was brought, time of planting and of ripening, amount of seed planted and of yield, with other important data, are presented in tabular form for convenience of comparison:

*Cultural value, etc., shown by foreign seed corn in Argentina.*

YELLOW VARIETIES.

| Variety. | Origin of seed. | Purity. | Germinative power. | Cultural value. | Weight of 1,000 kernels. | Weight per hectoliter. | Weight per bushel (Winchester). |
|---|---|---|---|---|---|---|---|
| | | *Per ct.* | *Per cent.* | *Per cent.* | *Ounces.* | *Kilos.* | *Pounds.* |
| Queen | North America | 99.38 | 96.50 | 95.90 | 10.09 | 72.10 | 56.01 |
| Pedrick's Golden | do | 99.10 | 92 | 91.17 | 15.97 | 69.80 | 54.23 |
| Golden | Italy | 98.40 | 93 | 91.51 | 6.19 | 81.00 | 62.93 |
| Precious of Auxonne | France | 99.12 | 71.50 | 70.87 | 5.47 | 75.93 | 59 |
| Canadian Flint | North America | 98.10 | 85.50 | 83.88 | 10.31 | 76.25 | 59.24 |
| Chester Giant | do | 99.20 | 89.50 | 88.78 | 12.67 | 71.00 | 55.16 |
| Lombardy | Italy | 95.96 | 60 | 57.57 | 16.11 | 71.47 | 55.52 |
| King Philip (brown) | France | 99 | 75.50 | 74.75 | 10.75 | 74.87 | 58.16 |
| WHITE VARIETIES. | | | | | | | |
| Hickory King | North America | 98.80 | 97.50 | 96.33 | 17.55 | 69.20 | 53.76 |
| Neapolitan Grand | Italy | 98.25 | 98 | 96.29 | 12.86 | 72.40 | 56.25 |
| Horse Tooth | France | 96.55 | 68 | 65.65 | 13.11 | 71.93 | 55.88 |
| White Head | North America | 99.40 | 78 | 77.53 | 13.62 | 69.00 | 53.60 |

The following is a summarized statement of the results with the varieties, showing the time of planting and ripening:

*Time of ripening, yield, etc., of foreign corn in Argentina.*

YELLOW VARIETIES.

| Variety. | Time of planting. | Seed planted. | Yield. | Time of ripening. |
|---|---|---|---|---|
| | | *Pounds.* | *Pounds.* | |
| Queen | November 1 | 4.4 | 418 | May.[a] |
| Pedrick's Golden | do | 4.4 | 330 | May.[a] |
| Golden | End of October | 4.4 | 264 | March. |
| Precious of Auxonne | December 1 | 4.4 | 176 | April. |
| Canadian Flint | End of October | 2.2 | 88 | March. |
| Chester Giant | November | 2.2 | 66 | May. |
| Lombardy | End of October | 2.2 | 88 | March. |
| King Philip (brown) | do | 4.4 | 209 | May. |

[a] Cultivated twice.

*Time of ripening, yield, etc., of foreign corn in Argentina*—Continued.

WHITE VARIETIES.

| Variety. | Time of planting. | Seed planted. | Yield. | Time of ripening. |
|---|---|---|---|---|
| | | *Pounds.* | *Pounds.* | |
| Hickory King | November | 2.2 | 165 | May. |
| Horse Tooth | End of October | 6.6 | 176 | May. |
| Neapolitan Grand | November | 4.4 | 110 | April. |
| White Head | End of October | 4.4 | 44 | (a) |

a Irregular germination.

All except Queen, Pedrick's Golden, and Precious of Auxonne were planted in land that had been used for wheat or linseed, mostly the former. The three exceptions were planted in new land. It is understood the planting was done with a drill, but that the rows were farther apart than is customary in Argentina.

OBSERVATIONS OF FARMER IN CHARGE OF WORK.

The comments of the man in charge of the experiment, who was a practical farmer, are given in substance as follows, touching each variety:

*Queen.*—Yellow dent. Very productive and suitable to locality. Imperfect grains and incomplete development of ends of ears, but would secure better results by earlier planting, without such heavy rains during first two months of growth. Excellent for distilling, feeding, and meal.

*Pedrick's Golden.*—Yellow dent. Productive. Grains well developed. Defective ears attributed to unfavorable weather in spring and at time of fertilization. Will do better.

*Golden.*—Yellow flint. Noted for its resistance to drought. Planted in November and December and matured in three months, with well-developed ears, even at the ends, notwithstanding the weather. Specially good for meal and for porridge.

*Precious of Auxonne.*—Yellow flint. Quick growing, three months' corn. Ears not so well formed and smaller yield; attacked by fungus. Used mostly for bread and porridge.

*Canadian Flint.*—Under favorable conditions will mature in less than ninety days, giving long ears of good grains, well formed and even. This variety is said to be well suited to the Argentine market, and to be excellent for bread and "polenta," or corn-meal porridge. In the present experiment the ears were badly formed and were attacked by insects. The variety is well known in the country, and has done well in many localities.

*Chester Giant.*—Yellow dent. Very luxuriant plants, suitable for green fodder, but badly developed ears, showing degeneration. Will do best in sandy soil. Best for fattening and distilling.

*Lombardy.*—Yellow flint. Excellent quality, much appreciated for the quality of flour it makes for bread and "polenta." In this case

the ears were few and not well developed, owing to the dry, hot weather at the time of fertilization.

*King Philip.*—Brown, or wine-colored, flint. Long, slender ears, and under ordinary conditions quite productive. It is well suited to some parts of the country, and has been grown successfully in the Provinces of Entre Rios, Santa Fe, and Cordoba. Its color seems to be against it in the market, though it makes good feed for animals and is valuable for distilling.

*Hickory King.*—White dent. Best of all white varieties known to experimenter. Well suited to temperate climate, though it has done well in Cordoba and even as far north as Bella Vista, in the Province of Corrientes, nearly 600 miles north of Buenos Aires. The ear is large, but badly formed and undeveloped at the top and bottom. It was not planted early enough to get a good start, and so did not have sufficient rain in its early growth; the heat and drought retarded its development and fructification.

*Horse Tooth.*—White dent. Good for all purposes for which corn is used, but in this case the result was not good. There was a very small yield of inferior ears, with badly deformed grains. It should have been planted earlier.

*Neapolitan Grand.*—White flint. Especially desirable for making bread, and hence useful in Argentina. This result was bad; it should have been planted earlier.

*White Head.*—Seed lacked strength and gave bad results, no grains being fit for seed. The ears were uniform, but the grains were deformed and degenerate. It is not of much importance.

GENERAL RECOMMENDATIONS.

Pedrick's Golden and Golden are recommended as the best of the yellow varieties, and Golden is especially recommended because dent corn is little appreciated in the Argentine markets at the present time. Commenting on this situation, the chief of the Division, Carlos D. Girola, says:

> It will be an error to abandon the cultivation of the dent corn, to which the farmers of North America are so devoted and with which they have been so successful. We do not understand why the exporters of corn in this country refuse the dent corn, when such a large proportion of the production and exportation of North America is of these varieties, which have been found so useful for distilling, for feeding cattle, and for making flour. We should now cultivate these varieties for our own consumption, for feeding animals, and for making flour. There is no doubt that this corn will be extensively cultivated in the future when it becomes better known and appreciated, and that it will be more favorably looked upon in the markets. When we have distilleries it will find ample use.

Farmers are urged to improve their methods, to plant the rows farther apart, and to cultivate the corn with more care. They are assured that by doing this they will be getting larger returns for their labor than in almost any other way. "It is a great error," this writer

says, "to suppose that by planting close together a larger crop may be had or the ground kept moist during dry weather."

Speaking of the varieties and quality of corn exported from Argentina, Director Tidblom, of the Division of Agriculture and Animal Industry in Argentina, says:

> European buyers of maize have, in ordinary years, a fancy for small-grained maize (corn) and are not sufficiently influenced in favor of really fine quality to pay an extra price to shippers. Therefore the shippers think mostly of the condition and safety for the voyage. If they can get the cargoes home in good order for immediate use, and of average color and plumpness, they are satisfied.

## CORN IN THE NATIONAL AGRICULTURAL SHOW.

The agricultural exposition given by the National Rural Society in Buenos Aires in May, 1903, was the first of its kind ever given in Argentina. Live-stock shows on a large scale have been highly successful for the past eight years, but agriculture has received but little attention. This first attempt at a national agricultural exposition was made in connection with the annual fat stock and horse show. It brought together some excellent collections of grains and other agricultural products.

Many samples of various varieties of corn were shown, usually as ear corn. The area from which the corn exhibits came extends north from Tandil, in latitude 37° south, 205 miles by rail south of Buenos Aires—or about the same as Richmond, Va., Wichita, Kans., or San Francisco—to latitude 25° south, including the remote northwestern province of Jujuy and the northeastern territory of Misiones. These latter are nearer the equator than the most southerly point of Florida or Texas.

From Tandil, which is a somewhat higher, cooler locality than the country farther west in the same latitude, came some Morocho corn, a white flint variety, that weighed 63.43 pounds per bushel of shelled corn (81.5 kilos to the hectoliter).[a] This was considered very good, as corn from the south had heretofore been light. From the Province of Entre Rios, on the Uruguay River, yellow cuarenton corn was sent that gave 64.49 pounds per bushel on new land. Some yellow flint was brought from Casares, 191 miles southwest of the city of Buenos Aires, that gave 65.2 pounds to the bushel. From Francisco Madero, on the same line 43 miles farther west, some Polenta corn was exhibited that weighed 65.9 pounds to the bushel. Specimens of Morocho were brought from southern Cordoba and from places not far from Buenos

[a] The quality of corn and wheat is judged in Argentine largely by its weight in kilos per hectoliter. The equivalents in weights per bushel are here given for convenience of comparison with American corn, which weighs 56 pounds per bushel of shelled corn.

Aires that gave 64.49 pounds to the bushel. Corn above this weight is considered remarkable. Well-formed ears were shown 11.8 to 12.6 inches long.

### CORN FROM TROPICAL REGIONS.

Some corn from the Territory of Misiones, raised in about latitude 26° to 27° south, more than 200 miles nearer the equator than New Orleans and 150 to 200 miles nearer than Galveston, Tex., caused some surprise. It was of a fair quality, not first-class, but good when the methods of cultivation are considered. The soil is a rich red, hardly ever, it is said, less than 3 feet deep, in many places more, and sometimes as much as 30 feet deep. The richness of this soil may be imagined, says the Rural Society's official report of the exposition, when it is known that the method of planting is to throw the seed on the ground without plowing, and then to scratch the soil a little with a pointed stick. This territory, the extreme northeastern part of Argentina, is one of the oldest, richest naturally, and yet least developed and most backward sections of the country. Its only means of transportation to market is the Upper Parana River, so the corn they raise is at present only for local use—to feed a few pigs and chickens. If with these primitive methods, without culture, corn of fair quality can be produced, what might be done on this land if corn was properly planted and cultivated, asks the writer of this report. In some places this land has been giving corn crops continually for eighteen years, and producing ears nearly a foot long. If the manufacture of alcohol is undertaken, utilizing some of the great water power in that part of the country, the growing of corn will, it is said. be greatly stimulated and will be more profitable.

The Province of Jujuy, in the other extreme of the tropical part of the country, sent some of the small Pisingallo corn and also some excellent samples of the larger white-flint corn, Morocho.

### A PROSPECTIVE CORN REGION.

It is predicted that the great Territory of the Pampa, southwest of Buenos Aires, which is already giving such good alfalfa, potatoes, and wheat, will soon be yielding good crops of corn in certain sections. Sir Thomas Holdich, the English engineer who settled the boundary dispute between Argentina and Chile, referred to the Pampa as "the granary of the world," he was so impressed by its possibilities.

### NORTH AMERICAN KINDS EXHIBITED.

Some samples of North American varieties shown by Dr. F. R. Cibils, chief of the Division of Commerce and Industries of the Argentine Department of Agriculture, prove that the Argentine soil and

climate are well adapted to the production of these varieties. One was a cross of Ohio Flint and Golden corn, producing a perfectly formed, thick, heavy ear, with kernels tightly set, fat, ripe, and hard. This crossed on White Mammoth, "the favorite dent," produced a longer ear, almost white, not quite as well developed at the tip, but still an excellent corn. Chester Mammoth Dent, yellow, gave the largest ears, about 12 inches long, but not so well formed nor as firm, and mixed with white kernels. Yellow Flint of Ohio turned out most satisfactorily, giving long, straight, uniform ears, with thick, heavy kernels closely set and developed to the very tip.

#### ADVICE TO FARMERS.

The conclusions of the author of the Rural Society's study of this exposition is that to the southwest of Buenos Aires and in the southern part of the Province of Cordoba are now the best corn fields.

Farmers are strongly advised to raise more corn and to raise hogs to eat it, as the most economical production of good pork requires corn feeding. On stock ranches, it is said, every pig that is raised along with corn-fed cattle is as good as each cow giving another calf, and it doubles the value of the corn harvest. The loss of the Brazilian market for Argentine pork products is attributed to feeding pigs on refuse and the consequent low quality of pork sent to market. Even now, the report says, very inferior products are consumed in Buenos Aires when the imported article is not to be had. Argentines are urged to produce more and better pork and to do it with corn. It is even claimed that two crops of corn might be grown in a year, the climate is so favorable.

## THE EXPORTATION OF CORN.

#### SHIPPING FACILITIES AND PROPOSED IMPROVEMENTS.

The facilities for handling grain in Argentina are inadequate, causing delays and losses, and increasing the burden which the producer must bear in getting his crop to market. Shippers must nearly always wait some days to obtain cars, which are distributed by towns, and the railway companies generally require shippers to state what ship the consignments are intended for before cars will be given them in the country stations to load for the seaports, Buenos Aires, Rosario, Bahia Blanca, or La Plata, especially the first named. The docks are so crowded during the busy seasons that the railway companies try to provide cars first for those who have ships ready to load, preventing speculators from cornering the market and filling the yards with grain in order to compel shippers who have ships waiting to pay them an exorbitant price for the grain they must have.

FREIGHT CARS AND CHARGES.

The cars are now being made larger and several of the principal lines have many 35 and some 40 ton cars; but there are still very many 10 and 15 ton English cars in use. Nearly all the railways are owned and, except for minor positions, operated by Englishmen. The railway companies allow three days for unloading cars, for which no extra charge is made; after that, $1.70 per day. The port of Buenos Aires allows six days free use of its yards for cars unloading; after that there is a yardage charge of 85 cents per axle, the cars having, according to their capacity, from two to four axles. No switching charge is made. Weighing is 12 cents per ton and loading on shipboard costs about 18 cents per ton.

PORTS OF BUENOS AIRES AND BAHIA BLANCA.

The port of Buenos Aires is so crowded that during the busy seasons ships are very often obliged to lie two or three deep alongside and carry loads across each other's decks. This is the more easily done because grain is always in bags, and if shipped in bulk is carried across to the ship in bags and the bags cut open on board. Sailing vessels are not allowed to have berths alongside when any steamer wants a berth. Very extensive improvements are in process of construction by the Great Southern Railway Company in Buenos Aires and Bahia Blanca, which will more than double the capacity of the present docks and moles, the latter being the form of structure at present in use at Bahia Blanca. The latter is a great natural ocean port. Its immense advantage over Buenos Aires, which is only at best a shallow river port, at the mouth of the River Plate, will make Bahia Blanca, with the rich and fast-developing country around it, the future great port of Argentina. The port of Buenos Aires must be constantly protected by dredging and is always liable to have low water, so that ships drawing more than 22 or 23 feet of water are not sure of being able to get out. The river is constantly building new bars and banks and adding to the land with the heavy silt which it carries. In June, 1903, a large European mail steamer was detained four days in the port of Buenos Aires because there was not water enough to get out. The Federal Government has improvements and extensions to the port of Buenos Aires under consideration, planned by Dr. E. L. Corthell, the distinguished American engineer, who was employed by the Government for two years to plan port works and river improvements. These improvements will be commenced in a year or so, when the necessary $10,000,000 can be secured, and will then afford ample room for all business. The present docks are built of granite, and are first class as far as they go.

RIVER PORTS.

The greatest shipping point, next to Buenos Aires, at present, is Rosario (Pl. V, fig. 2), 188 miles by rail and much farther by water from Buenos Aires. Ships drawing 24 feet of water can load at Rosario by simply lying out in the stream and receiving their cargoes by means of long chutes called "canaletas" (Pl. VI) from warehouses on the high banks. Nothing more is required. The Government, however, has provided for the building of docks there that were planned by Dr. Corthell and will cost about $10,000,000 gold. The work has been undertaken by a company that is to have the working of the docks and the custom-house there for a long term of years to pay for the docks. The Government does not put a dollar into it, except agreeing to keep the river channel between Rosario and Buenos Aires open for ships drawing 24 feet. At present ships can not safely load more than 18 feet in Rosario, because if they do they are liable to be detained for days on the bar at Martin Garcia, near the mouth of the river, above Buenos Aires. So the larger ships must take part of their loads in Rosario and go to Buenos Aires to complete, and on going in must leave part of their cargoes in Buenos Aires before proceeding to Rosario. The concessionaries have been for some months in possession of the port of Rosario, and are preparing to enforce their monopoly and stop all the cheap loading with chutes. (See Pl. VII.) They are now collecting all port dues, which have been somewhat increased. Many shippers expect to remove their business to other ports because of the increased charges that must necessarily be put on to pay dividends on the costly improvements now in prospect. The Parana River, on which Rosario is located, offers many natural ports for many miles along its high banks, and these are being improved to some extent and made ready to compete with Rosario. Grain men think they can pay freight to any of these small ports and load there cheaper than they can patronize the new port.

LACK OF ELEVATORS AND WAREHOUSES.

No conveniences for loading grain are provided in the country stations. There are no elevators and few warehouses, the latter almost invariably owned by private parties, usually buyers for their own use. There is no public storage for hire, to amount to anything, and if there was the farmers could not be persuaded to pay anything for the use of it. They are very much averse to paying out a single cent that can be avoided; they have not been educated up to the point of spending 10 cents to save $2, and they follow the practice of losing the $2 nearly every time. Grain is generally piled up in bags in the station yards, if cars are not ready, and it often suffers damage. Some of the railway companies, especially the Great Southern, have erected sheds for grain. The Argentine Congress has just passed a law requiring all

LOADING GRAIN WITH PORTABLE "CANALETAS" AT ROSARIO.

railway companies to provide free shelter for grain offered for shipment. The law went into effect on September 17, 1903, and allows the railway companies eight months in which to build sheds in all stations in the agricultural regions, as directed by the Department of Public Works. At the end of this time the railways will be liable for heavy penalties for failure to provide sheds, and are liable for all damages to grain offered for shipment that is due to lack of sheds. The railways are prohibited from making any charges for storing grain offered for shipment. This law is the outgrowth of the shortage of cars for handling the rapidly increasing grain business, and is intended to force the railway companies to handle the traffic more promptly. Elevators are now being considered and will be built within a few years, as soon as mixed farming becomes more settled and it is possible to say with more certainty what a section of the country will produce to give business for an elevator for any number of years together. Immense elevators are now being built in Buenos Aires and Bahia Blanca. There are several in Rosario, but they have not been in general use for several years. It is claimed the charges were prohibitive. One of them has been used by a corn-shipping firm for cleaning and drying corn, and with excellent results.

## METHODS OF LOADING AND SHIPPING.

### HANDLING AT PORT OF SHIPMENT.

Corn is usually exported from Argentina in bags of about 155 pounds weight. A year ago it was estimated that 90 per cent of the exportation was in bags and only 10 per cent in bulk. The proportion of bulk shipment is now somewhat greater. Sometimes cargoes contain both bagged and loose corn. In case of separate parcels in a ship belonging to different shippers, the bags are marked and piled separately.

In Buenos Aires and La Plata bags are either carried on board by men or swung on from cars alongside the docks by hydraulic cranes or steam winches. Corn to be shipped in bulk is always carried on board in bags and the bags cut open and emptied into the hold.

In Rosario several means are employed, chiefly the "canaletas," which are long, wooden chutes made in sections and swung on cables from the elevator or warehouse on the high bank to the ship lying in the stream below, as shown in the illustration (Pl. VI). In some cases grain has been loaded in bulk by the same system, with spouts. In another part of the port, where there are no high banks, the hydraulic crane and steam winches are used (Pl. V, fig. 2). In the smaller ports on the Parana and Uruguay rivers the "canaletas" are used.

At Bahia Blanca grain is loaded by steam winches from the cars, by men carrying the bags on board, and by a system of endless chains, carrying the bags a distance of about 100 feet from the cars to the ship's side, where they are slid into the hold. For handling in the dock

the charge is 35 cents gold, per metric ton of 2,204.6 pounds. For handling from the deck, either putting bags in the hold or cutting bags open and allowing the contents to fall into the hold, the charge is 16 cents gold, per ton. The commercial seaport of Bahia Blanca is 4.35 miles from the city. The railway company charges 65 cents gold, per ton for switching cars from the city yards to the shipping port. Another railway company has a mole also, and the switching charge between this mole and the city, 9.31 miles, over two railways, is $1.36 gold, per ton. The endless chains, working on two ships at a time, loading into all hatches, expect to load 1,500 tons of grain per day into a ship. It is a very dusty place, full of fine sand, which is very damaging to exposed machinery like this. The facilities are greatly inadequate, but extensive improvements now under way include huge elevators, large docks in addition to the present steel mole, and modern equipment for loading in bulk. The whole system is owned by the Great Southern Railway Company, the principal railway of South America, which controls transportation in the best part of Argentina, and is giving serious consideration to the construction of grain elevators and warehouses. Some lightering is done at Bahia Blanca when the mole is crowded and ships are waiting. The lighters are of 350 tons burden and the charge is 30 cents per ton. The bags are lifted from the lighters by steam winches on board the ships. Portable elevators are never used.

### OCEAN TRANSPORTATION AND CHARGES.

Corn exported from Argentina to Europe and England is generally carried in tramp steamers of from 2,500 to 6,000 tons burden, that require about thirty-five days for the voyage. Some shipments are made in liners or mail steamers, requiring only twenty-one to twenty-four days for the voyage. A very small amount goes in sailers, which require seventy to one hundred days to go to Europe, quite too long for grain shipments. Liners are preferred on account of their quick service, and they often take corn at low rates for ballast when the freight market is dull. Sailing vessels take corn to South Africa because, owing to favorable winds, they are able to make the voyage from the River Plate in twenty-five to twenty-eight days. Steamers do it in fifteen to eighteen days—usually fifteen.

The condition of the freight market constantly varies. Crop conditions, the wool market, favorable weather for handling corn, the demand for tonnage to Brazil and South Africa, as well as to the River Plate countries—all these things and other influences affect the supply, character, and price of tonnage from Argentine ports to Europe.

Liners bring general cargoes from Europe and carry back grain, hay, frozen or chilled meat, and other produce. They can not wait for cargoes, hence sometimes make liberal offers for business. Tramp steamers do a great variety of things, as the season and conditions

suit them. If they are assured in advance of a profitable return cargo they will come out from Europe in ballast, when the demand for tonnage for other parts of the world permits them to do so. Frequently they bring coal, and sometimes general or special cargoes. Often they bring cargoes to Brazil and go to the River Plate, 1,100 miles, or five days' voyage, in ballast. Recently quite a number have been going to South Africa loaded and crossing to Argentina in ballast. Sailers go in ballast to some United States or Canadian port and load lumber for Argentina.

### CARE IN TRANSIT.

Sometimes temporary wooden bulkheads are put in front of the engine room, leaving an air chamber a foot wide, which is kept full of fresh air to prevent heating the corn. But this is an unusual precaution, not the rule. Indeed, it is claimed that the corn next to the bulkheads, where there is most heat, often comes out the best. Occasionally a ship will be lined with straw matting or matting made of the tall rushes that grow in the Parana River, but this also is the exception, especially as most of the corn is bagged.

### RAILWAY FREIGHTS.

Freight rates in Argentina are high, compared with the United States. The railways, being nearly all English and owned by the same group of capitalists, have long and very favorable concessions from the Federal Government, under the supervision of which they all are.

The rates on corn on one of the principal lines were as follows in 1902:

*Freight rates by rail in Argentina.*

| Number of miles. | Rate per bushel in United States cents. | Number of bushels carried for 41 cents, at bushel rate. |
|---|---|---|
| 25 | 2.74 | 14.96 |
| 50 | 3.92 | 10.45 |
| 100 | 6.10 | 6.72 |
| 200 | 8.92 | 4.59 |
| 300 | 11.03 | 3.71 |
| 400 | 12.99 | 3.15 |
| 500 | 14.38 | 2.85 |
| 600 | 15.76 | 2.60 |
| 700 | 17.13 | 2.39 |
| 800 | 18.50 | 2.21 |
| 900 | 19.87 | 2.06 |

These rates are a trifle higher than those in force on some other lines traversing corn regions. Rates on Argentine railways are quoted in Argentine gold per 1,000 kilos (2,204 pounds), and are divisible in fractions of 10 kilos. Very little corn in Argentina is shipped more than 200 miles by railway, and most of it less than 100 miles.

Freight rates on corn in the United States in 1900, according to statistics published by this Department, were as follows, in cents per bushel:

Chicago to Buffalo by lakes, 1.71.
Buffalo to New York by canal and river, 2.31.
Chicago to New York by lakes, canal, and river, 4.02.
Chicago to New York by lake and rail, 6.44.
Chicago to New York, all rail, 9.19.
Atchison, St. Joseph, Kansas City, or Leavenworth to Chicago, 16 cents per 100 pounds, or 8.96 cents per bushel.
Atchison, St. Joseph, Kansas City, or Leavenworth to St. Louis, 11 cents per 100 pounds, or 6.16 cents per bushel.
St. Louis to New Orleans by river (in sacks), 10 cents per 100 pounds, or 5.6 cents per pushel.
Rates at present in force from Iowa points to Chicago are 17 cents per 100 pounds, or 9.52 cents per bushel, in carload lots.

### OCEAN FREIGHT RATES.

Ocean freight rates on corn from River Plate ports vary considerably according to the condition of the freight market. Now the range is from 8 to 20 shillings per shipping ton of 2,200 pounds. The charter rate from Buenos Aires, in good tramp steamers, is at present about 13 to 17 shillings per ton. From upriver points, such as Rosario or San Lorenzo, the rate is usually one shilling sixpence to three shillings higher because steamers may not always load to their limit there, but must stop at Buenos Aires to finish. They can not get across the bars on the way down with a full load drawing more than 18 feet, except at unusual stages of the river.

Rates in shillings per shipping ton of 2,200 pounds converted into cents per bushel, United States money, are as follows:

| | |
|---|---|
| 8s. per ton equals 4.95c. per bu. | 16s. per ton equals 9.91c. per bu. |
| 10s. per ton equals 6.19c. per bu. | 17s. per ton equals 10.53c. per bu. |
| 12s. per ton equals 7.43c. per bu. | 18s. per ton equals 11.15c. per bu. |
| 14s. per ton equals 8.67c. per bu. | 20s. per ton equals 12.38c. per bu. |
| 15s. per ton equals 9.29c. per bu. | |

The range of ocean freight rates on corn from New York and Boston to European ports during May, 1903, was as follows, in cents per bushel:

*Ocean freights on corn from United States to Europe.*

| To— | From New York. | From Boston. |
|---|---|---|
| Liverpool | 3.04 | 3.04 |
| London | 2.02 to 3.54 | 4.05 |
| Glasgow | 3.04 | 3.04 to 4.05 |
| Hull | 5.57 | 6.08 |
| Hamburg | 4.76 to 5.23 | 5.06 to 6.08 |
| Rotterdam | 3.00 | 5.06 |
| Marseille | 6.08 | ..... |
| Copenhagen | 8.11 to 9.12 | 8.11 |
| Havre | 9.12 | ..... |
| Genoa | ..... | 4.56 to 5.06 |

### EXTENT OF EXPORTS OF CORN FROM ARGENTINA.

Argentine exportation of corn from 1886 to 1902, inclusive, has been as follows, in bushels, with the valuation in United States money:

*Total exports of corn from Argentina, 1886 to 1902.*

| Calendar years. | Quantity. | Value. | Calendar years. | Quantity. | Value. |
|---|---|---|---|---|---|
| | *Bushels.* | | | *Bushels.* | |
| 1886 | 9,119,970 | $4,490,551 | 1895 | 30,404,504 | $9,836,571 |
| 1887 | 14,245,035 | 6,983,595 | 1896 | 61,827,888 | 15,434,756 |
| 1888 | 6,389,699 | 5,253,908 | 1897 | 14,760,664 | 5,286,963 |
| 1889 | 17,030,168 | 12,523,501 | 1898 | 28,230,887 | 8,949,600 |
| 1890 | 27,844,175 | 13,650,542 | 1899 | 43,945,394 | 12,586,479 |
| 1891 | 2,594,692 | 1,335,645 | 1900 | 28,079,045 | 11,516,066 |
| 1892 | 17,555,506 | 8,261,588 | 1901 | 43,788,911 | 18,226,338 |
| 1893 | 3,327,135 | 1,523,296 | 1902 | 46,959,122 | 22,189,268 |
| 1894 | 2,160,370 | 1,009,397 | 1903 (estimated Nov. 5) | 78,750,000 | 31,500,000 |

The distribution of Argentine corn exports for 1902 to the several countries of destination is shown in the following table:

*Countries importing Argentine corn in 1902.*

| Destination. | Bushels. | Destination. | Bushels. |
|---|---|---|---|
| United Kingdom | 11,658,515 | Spain | 305,731 |
| Germany | 4,738,985 | Brazil | 74,445 |
| Belgium | 4,252,870 | Other destinations[a] | 4,166,497 |
| France | 2,046,066 | For orders[b] | 18,759,099 |
| Italy | 966,914 | | |

[a] Including all other European countries and South Africa.
[b] Cargoes going to St. Vincent to receive orders to proceed to some European or English port, where the cargo has been placed during the voyage from the River Plate to St. Vincent.

## INSPECTION.

### LACK OF GOVERNMENT INSPECTION.

There is no Government inspection of corn in Argentina, for export or for any other purpose. The Argentine Department of Agriculture has studied the subject, and shippers, shipowners, and grain associations have been consulted, but nothing has come of it beyond the resolve to create a commission to look into the matter when the funds for such purpose can be spared. Grain exporters have not taken kindly to the idea. They do not want any Government interference with their business. Those who are taking the necessary precautions and shipping nothing but grain they know will go through without loss do not require any inspection. Those who are in a speculative trade, taking chances on buying poor grain at a low price, hoping to make a large profit if it arrives in fair condition, do not want the Government to injure their business by inspecting and grading this corn for what it appears to be before exportation. Often they lose heavily on these speculative cargoes, but the profit is so great if they succeed in getting them across without further damage that they will take long

risks. Cargoes arriving in bad condition often recover and are sold at better prices than the arbitration allowances. It is quite difficult, as the Argentine Government officials have found, to get the results of experience that has cost shippers thousands of dollars to acquire. They prefer to go on quietly making use of it themselves, leaving others to learn in the same way they did. But during a year's time the writer found many opportunities to learn and observe the methods employed by the most successful and conservative shippers of corn from Argentine ports to England and the Continent. They were quite willing to answer questions, and were kind enough to afford means for personal inspection of the details of their shipping arrangements.

### PRIVATE INSPECTION.

The only grain-inspection system in Argentina that is accepted in Europe and England is that established and conducted by an Englishman who served formerly as the English Government inspector of hay, bran, etc., bought in Argentina for the army in South Africa. This gentleman inspects all kinds of grain and hay for foreign buyers, and owing to his long experience in Europe, the United States, Australia, and Argentina, and to his conservative and thorough policy, his certificates are accepted, and cargoes passed by him have so far arrived in good condition. Offices are maintained in the principal ports of export, and inspectors are sent to other ports and to inland stations to receive grain and hay. Another inspection is made of grain and hay received in country stations before it is loaded on shipboard, because of the danger of damage, especially to hay, en route from the country stations to the seaboard. The prices charged for corn inspection range from 1 to 3 cents per bushel, according to the port or place of inspection and the amount of work required. When this system is not employed grain is sold from Argentina to Europe on "rye" or "tale quale" terms.

### GRADING CORN FOR EXPORT.

There is little grading of corn in Argentina for export, except such as is done by individuals. Corn that is suitable for export is known as "export type," being generally the small-grained, hard yellow or white, and dry and sound. Beyond these general requirements there is no common standard in the Argentine markets. Every buyer fixes his own standard according to his own ideas to fit the market in which he expects to sell. Corn is usually shipped under the denomination, "fair average quality at time and place of shipment, shipped in good order and condition." If the grain is exceptionally good, it is designated as "prime quality." In all cases it must be sound, clean, and dry enough, in the opinion of the inspector, to stand the voyage and arrive at destination in good order.

In the local markets there are three regular grades of the two principal kinds of corn known to commerce. Both "Maize Morocho," or white corn, and "Maize Amarillo," or yellow corn, are graded as follows: (1) Good to superior; (2) inferior to ordinary; (3) exportation type.

## PRICES.

The white corn has usually brought a trifle better price than the yellow, but more of it is now being produced than formerly and the price is about the same. The range of prices is not very wide. Corn is always sold by the 100 kilos, equal to 220 pounds avoirdupois. A sample quotation will show how the prices ranged, though at present there is not the difference in the prices of yellow and white corn. The quotations given here were in force in May, 1902.

*Prices of corn in Argentina in 1902.*

| Kind of corn. | Price per 100 kilos in Argentine paper money. | | | Price per bushel in United States money. | | |
|---|---|---|---|---|---|---|
| | Lowest. | Highest. | Average. | Lowest. | Highest. | Average. |
| White: | | | | | | |
| Good to superior | $5.80 | $6.30 | $6.00 | $0.64 | $0.70 | $0.67 |
| Inferior to ordinary | 5.00 | 5.80 | 5.50 | .55 | .64 | .61 |
| Exportation type | 5.35 | 5.70 | 5.50 | .59 | .63 | .61 |
| Yellow: | | | | | | |
| Good to superior | 5.20 | 6.00 | 5.50 | .58 | .67 | .61 |
| Inferior to ordinary | 4.40 | 5.50 | 5.00 | .49 | .61 | .55 |
| Exportation type | 5.35 | 5.40 | 5.35 | .59 | .60 | .59 |

These quotations range from 49 to 70 cents per bushel in United States money, the export yellow selling for about 59 cents per bushel. At this time corn was selling in Chicago for 57.3 cents per bushel and in New York for 63.3 cents per bushel.

In July, 1903, the prices in Argentina for the best export corn were around $4 Argentine paper per 100 kilos, or equal to about 44 cents per bushel in United States money. This is about 10 per cent lower than the prices at the same time in 1902. The prices in Buenos Aires November 7, 1903, were from 31 to 40 cents per bushel, or 40 to 41 cents for the best export type, about 20 per cent lower than on the same date in 1900.

The average prices for corn in the Buenos Aires market for six years ending with 1901 is given officially by the Argentine Department of Agriculture as follows, in cents per bushel, United States money:

| | Cents. | | Cents. | | Cents. |
|---|---|---|---|---|---|
| 1896 | 24.55 | 1898 | 34.31 | 1900 | 37.23 |
| 1897 | 44.44 | 1899 | 30.42 | 1901 | 48.62 |

The prices for 1902 were not available, but the average was not far from that of 1901.

### IMPORTANCE OF DRYNESS IN CORN FOR EXPORT.

The chief care of the shipper of corn from Argentina is to secure dryness, and that vital quality is harder to obtain than any other. It is not too much to say that three-fourths of the losses on Argentine corn going to Europe have been due to the dampness of the grain before it left the River Plate. The shipper has a constant fight to avoid receiving corn that is full of moisture; to keep it dry after he has received it; to get it on board ship in the same condition; and then to get the ship out of the River Plate before the cargo has absorbed much of the humidity that prevails there during the greater part of the shipping season. If the ship in which corn is loaded gets away within fifteen or twenty days after she begins to load, and the loading has been done with dry grain in dry weather, and the hatches of the ship are securely battened down and, as nearly as possible, hermetically sealed during the entire voyage, the general opinion among the most successful shippers now is that there is practically no danger of damage to the cargo during the voyage. They have largely abandoned the ventilation theory.

### CONDITIONS UNFAVORABLE TO DRYNESS AND CLEANNESS.

But many difficulties arise to prevent sending away corn under these favorable conditions. First, there is the faulty cultivation and harvesting, already referred to. Owing to these causes corn is slower to ripen and dry in the field than it should be and the inability of the farmers to get help for the gathering prevents them from husking their corn before the rains of June, July, and August have soaked it. The exception to this is the early corn that is gathered and marketed too soon. A comparatively dry winter is of great advantage to all who are interested in corn, but it is the exception. Of course there is no snow.

Shippers of corn usually send inspectors to the country stations to examine the quality of grain offered. This is done with a long tube, or spear, the same kind that is used for testing wheat. It is thrust into the bag, bringing out a section of the contents and showing its quality all the way through. This testing is done as the bags are being carried from the pile to the railway car, and it may be done again in the port. It requires considerable exertion and the sense of touch of the inspector is likely to become dulled after a time, especially if the condition of the corn varies much and a large proportion has to be rejected for dampness. Inspection is also often made in the "troja," or crib, before the corn is shelled, as the dryness of the cobs plays a very important factor in the dryness of the grain after shelling and it is easier to make sure about it in advance. The cobs being dry and shelling being done in dry weather, the maximum of security is obtained; but dry weather is not always to be had when machines are available.

Every effort is made to get the corn on board ship as soon as possible after it is shelled, but the country roads are generally bad at this season of the year, there is difficulty in getting cars, and often delay occurs in the port while the ship waits for her berth to load. All this time the corn is absorbing moisture more or less. A few shippers have tried to minimize the bad effects of this system by cleaning and drying the corn to some extent before shipping. The shelling machines in use remove the dirt very well, unless the corn is wet when shelled; but a great amount of "fluff," or chaff, is left with it, and this helps to create heat on board ship. Aside from this, Argentine corn comes to market fairly clean and not many complaints are heard on this score. Still, it is generally agreed among those who are well informed that it would be very much better if corn could be put through a cleaner or elevator for the removal of dirt, dust, and chaff that comes out easily within a few days after shelling.

### CLEANING CORN BEFORE SHIPMENT.

In Rosario two leading grain houses clean corn before shipping, chiefly to take out the "fluff," which they say contributes very much to the chance of heating on the voyage. One firm has leased an elevator at a low rental and uses no heat. They get an astonishing amount of chaff and small pieces of cob out of the corn—almost enough to furnish fuel for the engine that runs the elevator. This is one of the most conservative English firms, and is very careful not to buy corn on which there is a risk. They shipped many thousands of tons last year and not a single cargo went wrong.

Another house that does a very large business has put in an apparatus to dry as well as clean the corn. It is heated by hot air, and then passed through dry, cool air to take out the heat. But this is not altogether a success, because a certain amount of heat remains in the grain as it goes on board. It would not pay either of these firms to put corn through elevators at the current charges, they say, and no others do it. There is no kiln-drying. The cost of fuel would prevent it, if nothing else did.

### UNCERTAINTIES IN THE TRADE.

The most perplexing uncertainty exists in regard to the shipment of corn. It may appear to be dry, and yet not be. Sometimes when it is not it stands the voyage with but little harm. Heating and fermentation are produced by different causes and may be chargeable to qualities of the grain or to surrounding conditions. The line is not always honestly or intelligently drawn between harmless sweating and injurious fermentation. Complaints are made of the decisions of the arbitrators in Europe and England, that they have not so distinguished, and that cargoes have been sacrificed at much greater loss

than the true conditions warranted. It has been suggested that arbitrators should be supplied with samples, and should establish a standard distinguishing between corn that is really damaged and that which has only been discolored by the heating of the oil in the grain without damage to the starch therein. Isolated bags of bad corn may get in among many which are in good condition and cause great damage in spots. The imperfect formation of starch in corn in backward seasons, which can only be determined by chemical analysis, is another cause contributing to fermentation on the voyage. All these conditions have increased the reluctance of the Argentine Department of Agriculture to undertake to inspect and certify to the character of corn or other grain without having a thorough scientific study of the conditions made, with sufficient careful experimentation to remove all doubts.

### VENTILATION DURING THE VOYAGE.

Of one thing, however, the officials of the Department who have studied the problem are quite certain—that ventilation of a cargo of corn during the voyage is a very great error. This is the chief point of discussion among those interested in the grain trade, but the great majority of evidence, opinion, and practice is now against ventilation, as far as shipments from Argentina are concerned. Concerning the risks of the voyage, Señor Don Ronaldo Tidblom, chief of the Division of Agriculture and Animal Industry in the Argentine Department of Agriculture, has given me the following statement:

For what is called "ventilation" during the sea voyage it is customary to introduce damp sea air into the ship's hold: and, indeed, if such "reasonable precautions" are omitted, the shipowner is liable to damages for the heating of a cargo; although it is really absurd to think that there is any really effectual ventilation of a mass of grain, unless an elaborate system of pipes be provided for forcing air into every part of the holds: and practically this is impossible with bagged cereals when the spaces between the bags are filled with loose grain for better storage.

The state of the weather during the time of shipment is of great importance; because grain coming from the interior may absorb considerable moisture while waiting in railway cars or lying in the open holds of a steamer for some weeks at various river ports during a spell of damp weather. It is difficult to see how this can be avoided when steamers collect cargo at up-river ports, or wait for cars, because of the intense dampness of many days and of nearly all early mornings during the winter.

The absorption of moisture could be greatly avoided if all cars, on arrival, were discharged into closed warehouses, from which grain could be loaded with great dispatch by means of covered chutes, and the injurious effects of moisture would not have to be feared if the grain were kiln-dried before loading. Unfortunately, these closed warehouses and kilns have yet to be built.

Under the present conditions, after maize has collected moisture, perhaps for weeks, at the seaboard the steamer proceeds to tropical seas, where not only is the action of the sun upon the iron decks very severe, but also the water is hot and the air exceedingly damp. The hatches are removed occasionally and the ventilators are at work day and night pouring in fresh damp air. The idea is that "heated air will escape in the form of injurious gases," but what really happens is that it is

replaced by air containing oxygen, which assists in fermentation, just as fresh air assists in combustion in a furnace. If the holds were closed the air would soon be exhausted of oxygen and the process of fermentation would be correspondingly reduced.

It must also be borne in mind that heat alone will not injure maize and that a moderate amount of heat will evaporate a sufficient amount of moisture from a cargo during the voyage to improve it considerably if there has not been active fermentation. It is remarkable that Argentine maize carried in bunker holds, where it is subjected to moderate heat during the voyage, usually arrives in better order than the rest of the cargo. On the other hand, that part of a cargo which is under the direct action of the ventilating shafts is always in the worst condition. It is, therefore, not surprising that even good maize often fails to stand the ordeal of an extended ocean voyage, more particularly as it is shipped in cold weather and discharged in hot, or vice versa.

A great majority of shippers whose views were obtained and whose practices were observed were opposed to ventilation. There appears to be a modification of the ironclad rule of shipowners requiring ventilation, as stated by Señor Tidblom; since much corn is shipped with strict orders not to open the hatches, which are sealed as tightly as possible. The English firm in Rosario, referred to previously, sends all its cargoes that way.

### OPINIONS OF AN EXPERT.

The most thorough study of the question of handling corn that has been made in Argentina was that of Mr. William Goodwin, F. R. G. S., now retired and living in England. He was a little more than two years ago one of the leading grain exporters, and at the same time inspected grain and hay for shipment by others to Europe. He had a very large clientage in Europe and England and his certificates and opinions were received as authority. Having lived for many years in Argentina he had excellent opportunities for observation and study, which he used with good results. Mr. Goodwin has written numerous letters and circulars to the grain trade giving his experience and opinions about the best means of shipping corn to avoid loss by heating on the voyage. He has gone to the root of the trouble—the bad system of cultivation—and in a formal article in the official bulletin of the Argentine Department of Agriculture he gives much good advice to corn raisers in Argentina. One of their worst mistakes, he says, is in planting more than they can properly care for or harvest. They begin gathering too early, before there is any frost to perfect ripening, and later are unable to get help to gather in the best months. The husking is carelessly done, often on rainy days and early in the morning when it is wet, and wet husks and dirt are taken with it. Farmers are advised to undertake no more than 110 to 130 acres to a family and work it better.

Often it is impossible to fill a ship with a good quality of corn, and at last the cargo is completed with grain that should never have gone

in. Probably the ship has been waiting for many days, badly and slowly loaded, with open hatches in wet weather. She may be overloaded at Rosario and have to wait a week or more for high water to cross the bar at Martin Garcia, just above Buenos Aires. In this way the cargo is given every opportunity to absorb moisture before sailing. This generally results in heavy losses at the point of destination.

Mr. Goodwin is quite sure that if ripe Argentine corn is shelled in dry weather and loaded promptly on a ship sailing at once, with the hatches tightly closed during the entire voyage, there will be no trouble at destination. He says it is "not only richer in food constituents, but of much better carrying nature than either North American or Danubian maize." Shipments must be made from Argentina before summer, because in the intense heat the "maize fly," or "palomita," and various micro-organisms develop. Besides, the wheat crop is then demanding the attention of the farmers, and wool shipments are at their height.

Under date of March 10, 1901, Mr. Goodwin, in a circular to the grain trade, expressed the following opinions concerning the shipment of corn and ventilation on board:

A seed grain must be considered as a living entity, composed of minute cells, although its activity of life can be suspended for a long time under certain conditions; and we must study the most practical and economical method of providing those conditions.

It may be roughly said that moisture, air (oxygen), and sufficient heat are necessary for animal or vegetable life, including micro-organisms, and that the active life of a seed can be suspended for a time if any one of the three be withheld.

Of course the best thing to do with grain is to make it really dry and keep it so; but apart from the difficulty of this work in damp weather, on farms or in ordinary warehouses, it must be remembered that grain, especially maize, absorbs moisture from the atmosphere, and also that somebody loses money when grain loses weight. Furthermore, there is a point beyond which drying is unnecessary for the after processes of milling, etc.; and it may be more economical to exclude the second factor, air.

At this point we come to consider the reasons for what is called ventilation on board ship and to note that when grain is thoroughly exposed to air it does not suffer from an excess of heat, as for instance, when in thin layers on a warehouse floor, or when bags are stowed in open order, and in that way it is protected from fermentation, but not from moldiness.

The ventilation in a steamer's hold has a very local and partial effect on the entire mass of grain, and was designed for letting out gases, being advisable for coal cargoes, but without any scientific reason for grain cargoes; and cargo surveyors say that the greatest amount of damage is to be found within range of the ventilators, the least being at the bottom of the hold where there is least access of air, of course always supposing the grain to be of similar quality and condition. In fact, it may be said that ventilation, if thorough, is effective, but if partial is very dangerous.[a]

[a] In another and subsequent article, of an official character, Mr. Goodwin said: "It is dangerous to trust ventilation to any one but an expert. It is easy to let out heated, expanded air, but if cold, damp air is admitted it will increase the fermentation. If a competent person was in charge, possibly a little ventilation during hot and dry weather might be good, but as a rule it is to be guarded against."

**Heat, the third factor,** may come from the sun, but on board ship may be the result of some grains germinating, or else it comes from direct fermentation. The heat generated in brewers' vats is well known, and Pastèur demonstrated that it is microbic action, but we do not always consider that the mechanical action of a growing seed develops a considerable amount of heat, and this heat may, in a grain cargo, cause fermentation.

The investigation of what is called heating of grain is complicated early in the season by what is called "sweating," a natural process happening at uncertain periods, which has so far not been scientifically explained. We know from experience that grain is improved by sweating and loses moisture, so that fresh grain may sweat on board ship and yet arrive in good order; also, that it should not be disturbed during the process, but it is sometimes difficult in practice to distinguish from fermentation, and further information is badly wanted.

In another circular Mr. Goodwin said:

Ventilation (before shipping) is especially necessary for the removal of the fluff and the mealy dust which comes from the point of the maize grains, which can not be properly removed at the time of shelling and causes much of the heating afterwards. A few frosts are always to be counted on to kill the plants: but there is nothing answering to the winters of the United States; although during October and November the weather is almost always suitable for shipments, and by that time the grain has become dry. With December, however, comes wheat harvest and also considerable heat, which develops weevils and maize fly, and prevents the carrying over of grain to another year; so that under the present conditions of the trade there are only some three months of entirely good weather for shipping an export surplus that may any year amount to 2,000,000 tons.[a]

ANTISEPTIC GRAIN STORAGE.

In September, 1900, Mr. Goodwin published the following letter in London advocating the shipment of corn in chambers sterilized with carbonic acid gas:

Business men are sometimes slow in making practical use of scientific discoveries: and although a large quantity of grain, and especially Argentine maize, that is shipped in apparently good condition, arrives in Europe heated and decayed, the real cause of this trouble does not seem to be studied according to the lights of modern science; nor is the fact that Indian peasants can keep their grain for many years in underground pits appreciated properly.

Some twenty-five years ago Pasteur demonstrated that fermentation does not result from the generation of gases, but from the action of living microbic organisms; and it is now known to bacteriologists that some 95 per cent of the germs which cause fermentation in grain require oxygen as well as a certain amount of heat and moisture for their development. It is also known that under favorable conditions their rate of increase is prodigious.

The vitality of these germs can be suspended by a sufficiently low temperature, as is done in refrigerator chambers for fresh meat; and although it is impracticable to apply cold storage to cargoes of grain it should be easy to sterilize the air in the holds of a steamer sufficiently to retard fermentation without causing any injury to the grain or to the crew, if suitable precautions are taken. On the other hand, what is called "ventilation" of the holds is surely a grave error if Pasteur is right, and must assist fermentation just as the admission of fresh air assists combustion in a furnace.

[a] The exportation of the present year will, it is estimated, equal that amount.

It is interesting to note the arrival last week in London, free from weevils and in perfect condition, of a cargo of Argentine maize which appears to have been treated antiseptically; and this has occurred at a time when all other Argentine maize cargoes are arriving in bad order and when claims for damage during the voyage have been settled for some £12,000 in one week.

Attention has been called to this cargo because a grain sampler, who, without permission, removed the hatches of one of the holds and went down, became insensible and died forty-eight hours afterwards from the effects of inhaling carbonic acid gas. Evidence was given at the inquest to the effect that the maize had been sprinkled during shipment with some chemical preparation and that the holds had been kept closed during the voyage. A verdict of accidental death was given, but the jury censured the shippers for using chemicals and the captain of the steamer for having allowed them to do so, and also for having neglected to ventilate the cargo; a verdict that may have unpleasant after consequences, because of precedents established by the rulings of judges.

About three years ago the owners of the steamship *Belasco* were condemned to heavy damages because some of the hatches and ventilators were closed during the voyage; and many steamship owners immediately gave their captains notice that they must be able to prove that ventilation had been provided and used, notwithstanding any instructions to the contrary on the part of shippers of the cargo.

Chemists say that inexpensive compositions of a perfectly harmless nature in their after effects on human food can be used to sterilize an air chamber—that is, either to consume or drive out the oxygen contained in atmospheric air—and that their application to the holds of a steamer or to suitable warehouse silos would only need reasonable precautions: but it is very desirable that some joint action be taken by grain trade and steamship associations, not only to arrange for a careful study of the entire subject in order to ascertain what methods are safe and efficacious, but also to protect, as far as possible, from unfair legal penalties shippers and others who make the necessary experiments; because when juries or arbitrators have to decide on cases of death by misadventure or damage to produce there is always a tendency to deal harshly with any departure from old methods.

The logical sequence of Pasteur's discovery should be a radical change in the method of storing grain, and indeed nearly all other food products; and it would appear that the air in storage chambers, at sea or on land, can be more economically sterilized with carbonic acid gas than by any refrigerating process. The subject being of national importance calls for proper investigation.

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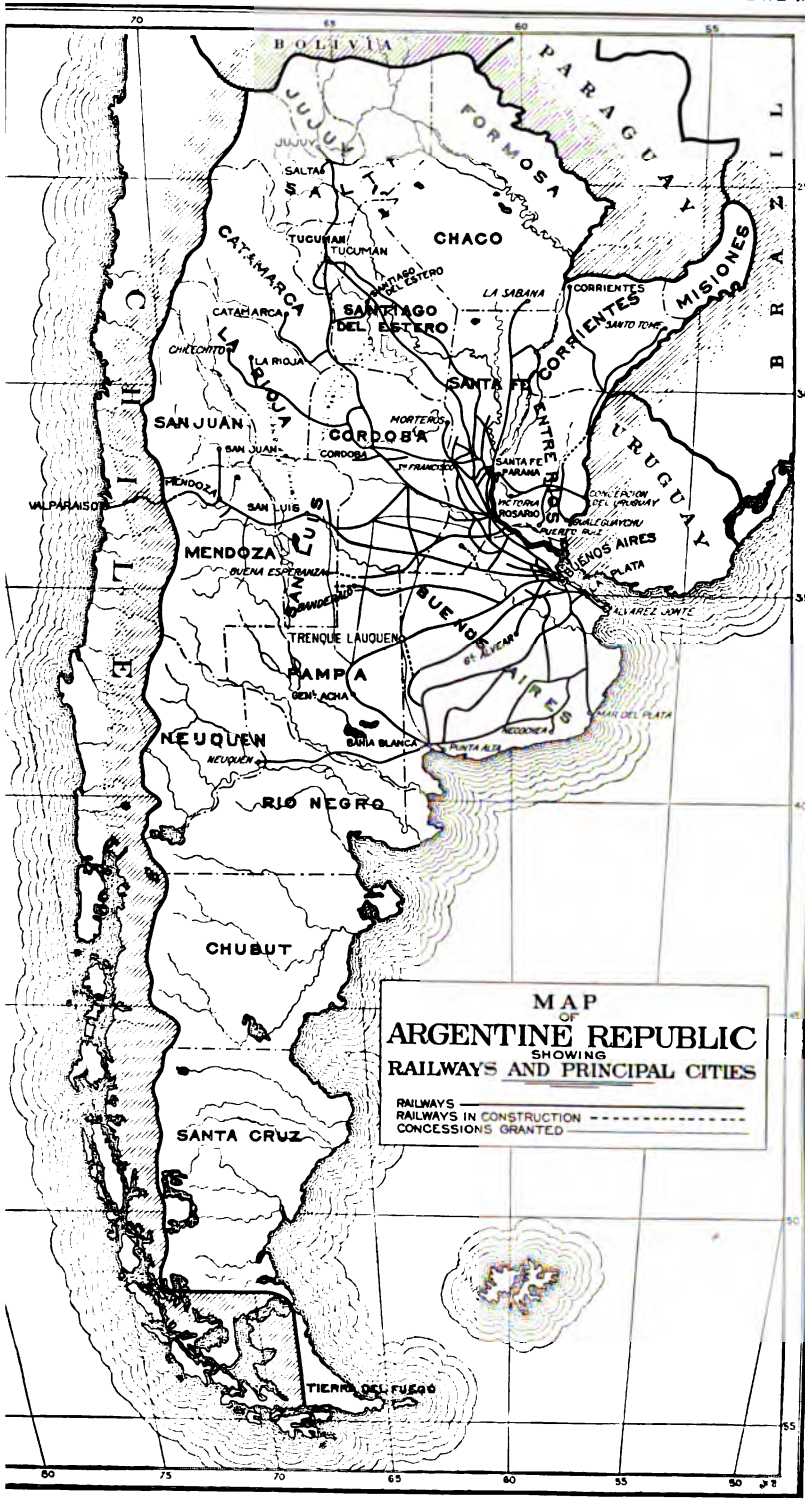


ARGENTINA: PROVINCES, RIVERS, RAILWAYS, AND PRINCIPAL CITIES.

U. S. DEPARTMENT OF AGRICULTURE.

Report No. 77.

# ALFALFA AND BEEF PRODUCTION IN ARGENTINA.

BY

FRANK W. BICKNELL,
SPECIAL AGENT.

WASHINGTON:
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1904.

## ARGENTINE TERMS AND MEASURES USED.

For the convenience of the reader in the United States all terms and measures employed in this report have been converted into terms employed in the United States, except where otherwise expressly stated. Some terms and expressions in use in Argentina, or having a special meaning there, are occasionally used, and these are herewith explained.

*Money.*—All expressions of value, unless otherwise stated at the time, have been converted into United States currency. The Argentine gold dollar is worth $0.965 in United States currency. The paper dollar, which is the general circulating medium, is worth about 44 cents of our money. All transactions in Argentina are in paper money unless gold is specified.

*Metric system.*—The metric system of weights and measures is in use in Argentina, and is the only legalized system. Some of the old Spanish or local terms are still in use, however, especially in the country. The kilo, abbreviation of the word kilogram, is the standard unit of weight, and is equal to 2.2046 pounds avoirdupois.

*Land measurements.*—The official unit of land measurement is the hectare, equal to 2.471 acres. A "square" of land is equal to 4.17 acres, and this old term is in very general use. The common understanding of the "league" of land is a square league, equal to 6,672 acres. A kilometric league of land, the official measurement, is equal to 2,500 hectares, or 6,178 acres.

*Estancia and estanciero.*—An estancia is, primarily, a stock ranch, and the owner and operator is an estanciero. But the estancia may include other things. It may also be a breeding establishment or that only. It may deal in cattle, horses, or sheep, or all three, either for sale in the open markets for beef or mutton, or for feeding stock, or for breeding purposes, or all these. Cereal production and hay making may be added to these, and sometimes this may be the most important part of the estanciero's business. So in translating it is impossible to say in a single word just what is meant. In this report the words estancia and ranch have been used synonymously, also the words estanciero and ranchman.

*Chacra and chacarero.*—A chacra is a farm on which cereals or other crops are raised, as distinguished from the estancia or stock ranch. The chacarero is the farmer or man who operates a chacra.

*Camp.*—In Argentina people speak of the country outside of the cities as the "camp." They say, "I am going to the camp," where we would say, "I am going to the country." The word is also used in speaking of the land—as, for instance, "My camp is in good condition," or "The alfalfa camps are holding out well."

*Alfalfar.*—An alfalfa field.

*Frigorifico.*—A meat-packing establishment where cattle and sheep are slaughtered and the carcasses either frozen or chilled for export.

# LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
*Washington, D. C., January 8, 1904.*

SIR: I have the honor to submit herewith a report upon the influence of alfalfa upon beef production in Argentina, to which I have added some late information concerning the market for pedigreed stock in that country. The opportunity for our breeders was never as promising there as it is now. I therefore respectfully suggest that this report be printed for the guidance of the breeders of the United States who may wish to enter that market. Argentines are very eager to secure first-class breeding stock, and the English breeders who have been supplying the demand have found the business highly profitable.

This report is supplemental to my bulletin on "The animal industry of Argentina," printed as Bulletin No. 48, Bureau of Animal Industry.

Acknowledgment should be made to the following-named gentlemen in Argentina, whose intelligent and willing cooperation made this report possible: John Benitz, Glynne Williams, Eduardo Bullrich, William O. Benitz, Henry B. Coffin, Leonardo Pereyra, Ronaldo Tidblom, Alfredo Benitz, Dr. Enrique Fynn, jr., Arturo Bab, Adolfo Aymerich, Alfredo Sanders, J. Charles Pearson, Latham Hall, Nicolas Calvo, and C. A. Roberts.

Respectfully,

FRANK W. BICKNELL,
*Special Agent and Agricultural Explorer.*

Hon. JAMES WILSON,
*Secretary.*

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# ALFALFA AND BEEF PRODUCTION IN ARGENTINA.

## ALFALFA GROWING AND ITS RELATION TO CATTLE RAISING.

### INTRODUCTION.

Without alfalfa Argentina would occupy an unimportant place as a beef producer in the markets of the world. Alfalfa has redeemed to profitable use millions of acres of Argentine land that would otherwise be unproductive. Alfalfa sends the Argentine steer to market a year younger than when the native grasses were relied upon exclusively. In many places, especially in the northern part of the country, it has made money for the small farmers, or "colonists," who have cut it and sold it for hay for export or for domestic use. Cattle raisers have learned its value in a dry, cold winter, when the pastures have failed, and but for the alfalfa hay, put up by the provident against such an emergency, hundreds of thousands of cattle would starve. But this marvelous forage plant is valuable in Argentina chiefly because it gives a rich fattening pasture on land that is otherwise of small value. Alfalfa is the only plant that will send its roots down deep enough to get the moisture necessary to growth.

### GROWING OF ALFALFA AND PRICE OF LAND.

It is the ambition of nearly every ranchman, or estanciero, to get as much of his place into alfalfa as possible, and the area of alfalfa pasture is increasing enormously every year. In some sections it is still in an experimental stage and in others it has proved a failure, at least for pasturage; because "tosca," a limestone formation, is too near the surface of the ground or because native summer grasses overcome it. But the failure of wheat in the northern part of the Province of Santa Fe (Pl. I, frontispiece) has driven small farmers to turning their wheat farms into alfalfa fields or to moving to another part of the country, either to raise cereals under more favorable conditions or to go into alfalfa where experiments have shown that it will succeed. Farmers in the same region who, instead of putting all their land into wheat or flax, have planted alfalfa and corn and raised cattle have done well. As soon as a brief experiment demonstrates the adaptability of a new region to alfalfa, there is a grand rush to get in.

Land jumps up incredibly in value; thousands of acres often change hands several times in a year, with valuations doubled at each exchange. This was the case in 1902 with lands in the central part of the Province of San Luis, 425 miles by rail west of the city of Buenos Aires. It was found that alfalfa would grow very well there, and the lands were wanted by men owning large cattle ranches (Pl. II) in the Province of Buenos Aires, where they could not afford to fatten their steers. They wanted cheap alfalfa lands to which they could send their young steers to fatten and on which they could breed others.

Alfalfa for pasturage for fattening cattle is not grown so much in the Province of Buenos Aires, where land is most valuable and the country most settled. There are several reasons for this, the chief ones being that they have good, rich, native summer and winter grasses (Pl. III) and do not need the alfalfa so much, and these native grasses exterminate alfalfa in a few years. Besides, the winters are longer and colder in Buenos Aires than in the alfalfa regions north and northwest, and land for alfalfa is much more expensive in "the Queen Province," as Buenos Aires is called.

### METHODS AND PROFITS IN GRAZING ALFALFA.

The system now generally coming into vogue is to raise feeders in the Province of Buenos Aires and in the far north, to be taken to the alfalfa camps (fields) to fatten. In the south of Buenos Aires the winters are so long and severe that it is not the rule to fatten steers, but to sell them at 2 years of age to go to the alfalfa camps for eight to twelve months' feeding. Estancieros in southern Buenos Aires say that unless steers are housed there they have very little chance of becoming fat. Still I have seen some very good looking steers, Polled Angus and Shorthorn, in this neighborhood, 20 miles east of La Colina, which is a little less than 300 miles south of the city of Buenos Aires.

The following is the opinion of an alfalfa ranchman of wide experience and notable success in the Provinces of Santa Fe and Cordoba:[a]

> You can buy a league (6,672 acres) of virgin land for $11,000, or $1.65 per acre and, by spending as much more in putting it into alfalfa, have a ranch that will carry 3,000 cattle and keep them practically fat all the year round, with very little risk from drought or severe winters. These provinces that grow alfalfa so easily (Cordoba, Santa Fe, San Luis, and western Buenos Aires) are the future

[a] Mr. John Benitz, who went from California to Argentina thirty years ago, and with his brothers, William and Alfred, has been very successful with alfalfa and cattle. On their home estancia, "La California," about 70 miles northwest of the city of Rosario, they were the pioneers in the planting of alfalfa, and were among the first, if not the first, to have a league of it. The one quoted is now working about 60,000 acres in alfalfa in southern Cordoba.

BRICK BARN FOR CATTLE, GRAIN, AND HAY, NORTHERN BUENOS AIRES.

FIG. 1.—HERD OF 5,000 GRADE DURHAM COWS ON NATIVE GRASS, 160 MILES WEST OF THE CITY OF BUENOS AIRES.

FIG. 2.—SHORTHORN COWS AND CALVES ON NATIVE SUMMER GRASS, NORTHERN PART OF THE PROVINCE OF BUENOS AIRES.

grazing lands of the Republic. It is astonishing what large areas are taken up every year and turned into alfalfa, to be stocked with the best cattle to be purchased in the Province of Buenos Aires. Cattle develop here better than on the finest natural grasses of the Province of Buenos Aires.

## THE REGION OF ALFALFA GROWING.

Alfalfa is grown all over the Province of Santa Fe, except in the extreme northern part, north of latitude 30° south; in all the Province of Cordoba south of the city of Cordoba and in mountain valleys north of the city; in most of the Province of San Luis, where it is fast increasing; in the northern part of the Territory of the Pampa; more or less, either for hay or grazing, in the entire Province of Buenos Aires, especially in the west and north (Pl. IV, fig. 1); to some extent in the Province of Entre Rios, where it has not done so well; in the irrigated and fertile valleys of the rivers in the southern territories of Rio Negro, Neuquen, and Chubut to a limited extent; and small areas in the northern provinces of Mendoza and San Juan. It is at its best in southern Cordoba, Santa Fe, San Luis, and western Buenos Aires.

## SEASON AND METHODS OF SEEDING WITH ALFALFA.

Most of the seeding with alfalfa in Argentina is done in the fall, in the months of March and April,[a] where it is sown alone, or two or three months later where sown with cereals. The difficulty of preparing large areas for sowing early in the fall operates to postpone the sowing, as the great saving in expense leads farmers, especially estancieros, or large stock farmers, to sow with wheat or flax, or sometimes barley or corn. Harvesting and thrashing cereals are hardly finished during January and February, and hauling to market is not done till the end of February or well into March. This makes it difficult and expensive to get the land plowed for alfalfa sowing in March or April. Besides, the land is likely to be too hard to plow till after the first fall rains. There is no doubt, however, that the best results are secured by sowing at this time and without the nurse crop. The heat of the summer is over by the last of March, and the alfalfa plants get a good start before frost and the dry winter months of the northern region. In the spring the alfalfa is strong enough to smother any grasses or weeds that may come up. This is the general opinion over the country, though one very successful alfalfa grower in the Province of Buenos Aires, not far from the city, sows in August or September. His land is more sandy and probably does not encourage the growth of weeds to the extent that stronger soils do.

[a] It must be remembered throughout this report that the seasons are those of the southern hemisphere, the reverse of seasons in the United States.

SOWING ALFALFA WITH A COVER CROP.

A great majority of the ranchmen of Argentina who raise alfalfa consider the advantages of sowing it in June or July with wheat or flax to be so great that a very large part, probably three-fourths, is sown that way. The objection to this plan is that the plants do not get a good start in this sometimes dry and always cold season; that the wheat chokes the alfalfa back until after the wheat is cut, when the rain and heat stimulate weeds that sometimes overcome the alfalfa. The same amount of seed sown without a nurse crop will give more and better plants than with it.

But when a ranchman has a large area that he can get into alfalfa in two or three years without any expense to himself, the land paying him an income in the meantime, he is very likely to adopt that method, though it does not give quite as heavy a stand of alfalfa at first. For the man who is short of working capital there is no other practical way. The system prevails all over the country where cereals and alfalfa do well in the same region, but is less followed in the south of Cordoba, the best alfalfa country, and not at all in the newer regions in San Luis. Ranchmen (estancieros) in the Province of Buenos Aires, who have large areas in native grasses, are turning the land over to colonists, or renters, who raise wheat on it for two or three years, under a contract that requires them to sow alfalfa with the wheat the last year, the seed furnished by the landowner. Thus he gets the best results with wheat, and the land is handed back to him covered with alfalfa.[a]

So much of this has been done that it has led many cattlemen to the opinion that agriculture is only transitory, and that the future of Argentina depends upon cattle and alfalfa; but they admit now that they must have corn to finish their steers. An English estanciero, Mr. Glynne Williams, who has a large place near Coronel Suarez,

[a] Señor Ronaldo Tidblom, Director of the Argentine Bureau of Animal Industry, gives the following account of an operation of his own as a practical estanciero:

"I have sown 42,000 acres of camp with wheat and alfalfa in the south of Cordoba and Santa Fe, where I could only keep 1,200 breeding cattle per kilometric league (6,178 acres), with a gross profit of $308,012, with a total expense of $208,741 and net profit of $99,271, said camp having now a carrying capacity of from 6,250 to 7,000 breeding cattle per kilometric league. The pastoral grass is burned, the land plowed and well harrowed in October, November, December, January, and February; it is plowed deeply a second time in May, June, or July, harrowed, the wheat seeded thin, and again harrowed; the alfalfa is then seeded at 22 pounds per acre, the land harrowed with chain harrows and then rolled. The alfalfa germinates more or less at the same time as the wheat; the wheat is harvested in December and cut as low as possible, and the land is allowed to lie until the following September or October, our spring, when it is eaten bare by cattle, and is then ready to produce hay or pasture, as may be desired. This is the means of increasing five, ten, and even fifteen fold the carrying capacity of thinly grassed rough lands, giving a profit during the transformation."

This is a more elaborate system than that in general use, however.

about 300 miles south of the city of Buenos Aires, where he carries on mixed farming, wrote in May, 1903:

Last year I harvested 30 bushels of wheat per acre on a piece where this year I have very good alfalfa, while the alfalfa which I sowed with the wheat last year looks extremely well to-day. The advantages of sowing with wheat are obvious in the saving of another plowing and, far more than this, in the saving of time and having the alfalfa for the winter after the wheat is cut, which is the time when feed is most wanted. Until I see far more decided advantages than I do at present in sowing alone, I intend to continue sowing with wheat, so long as the latter remains a paying crop. As far as my experience goes there is no objection to grazing alfalfa with cattle while it is young. To do so with sheep and eat it bare would, I think, be dangerous, as they crop it too closely.

Mr. John Benitz says, concerning southern Cordoba, where he is now working about 60,000 acres, mostly in alfalfa:

I have had the best results by breaking up virgin camp in the fall or spring and at once cross disking, harrowing, and sowing with alfalfa alone and covering it with a lighter harrow. Alfalfa so sown can be stocked with cattle two or three months after sowing, fed down close and trampled. Then the stock should be taken off for a few months, and the alfalfa will grow splendidly. The ground being new, no grass or weeds come up. If alfalfa and wheat are sown together cattle can not be put on till a year after, but if sown alone cattle can be put on permanently when it is six months old.

In the north of Santa Fe, in the Jewish colony at Mosesville, the manager told me that it was not advisable to sow alfalfa there on new soil, and that a previous culture with corn, flax, or wheat was to be preferred.

### GRAZING ALFALFA WHEN YOUNG.

The opinion seems to be quite general in Argentina that more or less feeding is good for alfalfa when it is young, certainly by the time it is five or six months old, as the tramping is beneficial and the plants should not be allowed to go to seed the first year. Sometimes sheep are put into the alfalfa pastures with an attendant to keep them moving and prevent them from eating too closely. They eat the weeds and do a fine job of tramping. Mr. Williams says that during a good spring it is impossible to keep the alfalfa down with grazing because the appliances for watering stock are not calculated for the number it would then carry. On a piece sown with wheat which gave 30 bushels to the acre last year he had for some time last spring, or less than a year after the wheat was cut, four to five animals, yearling calves and old cows, per hectare (2.471 acres), and he was at the same time cutting some of it for hay. In May, 1903, he had rather more than one cow per hectare fattening. Later on, if the weather got very dry and cold, he might not be able to keep any stock on it for a time. Some stockmen cut the alfalfa the first year and do not allow stock on it until it is about a year old. The difference of opinion on this point is due to different conditions and to overstocking young alfalfa. It requires experience to know how far to go with the feeding.

### AMOUNT AND PRICE OF SEED.

The amount of seed sown varies greatly according to locality, individual opinion, and whether land is old or new. The amount per acre ranges from 9 to 35 pounds, generally from 11 to 18 pounds. More seed is used on old land than on new, though 18 pounds per acre is sown in southern Cordoba on new land without a nurse crop. The price of seed varies considerably, according to the season, for now it is all produced in the country. Seed is harvested in southern Cordoba, Santa Fe, and western Buenos Aires, while very pure seed is raised in Chubut in small quantities. A yellow butterfly or rain at the time of fertilization sometimes destroys the crop of seed. A dry season, checking the growth, is favorable to the production of seed, but it is not considered advisable to allow alfalfa to go to seed more than once in five years. Some ranchmen believe in letting it go to seed and resow itself. Seed is sold by the 10 kilos (22.046 pounds), and the price is from $1.42 to $2.84 United States money for that amount, or $3.35 to $7.70 per bushel of 60 pounds.

### LIFE OF ARGENTINE ALFALFA.

More variation is found in the number of years alfalfa will live in Argentina than in any other feature of the business of growing it. Bad seasons and close feeding may wear it out in three years in some localities, while in other places fields that are cut only will live for twenty-five years and still make a good showing. The latter is a very rare and extreme case, and the former is quite unusual, except where the pasture has been abused. Alfalfa lives longest and gives best results in the light soil of the upper provinces, in western Buenos Aires and in San Luis. The strong native grasses, which after a few years overcome alfalfa in the Province of Buenos Aires, do not exist to the same extent in Cordoba, Santa Fe, and San Luis. The soil is not rich enough to sustain them, as they do not reach down for the moisture, so there is little to interfere with alfalfa in these regions. In Buenos Aires, from the city south, estancieros estimate that alfalfa, used only for cutting, and well cared for, will live from five to ten years, differing according to locality and seasons. One, who lives near the city and has a very large breeding establishment, manures his alfalfares, and they last seven or eight years, but he does not put cattle on them. If constantly fed, the life of the pastures in this province, except in the west, is not more than three or four years. The native grasses come up and choke it out.

In southern Cordoba alfalfa with ordinary care will last fifteen years, but if fed short it may be completely killed out in five years. It is said that cutting instead of grazing improves it by allowing it to come up to its full height, which is life to alfalfa. In the Province of Santa Fe estimates of the life of alfalfa range from three to twenty-five years, depending upon the seasons and how it is treated. When

cut often and not stocked with sheep and little or not at all with cattle, the estimates of its life are from ten to twenty-five years, with the majority around fifteen years.

In the Jewish colony in upper Santa Fe they say ten to fifteen years if cut only, or six years if fed. Indeed, Don Arturo Bab, the manager of the colony, says that there does not seem to be any limit there to the life of alfalfa that has been continually cut and fertilized by turning on cattle only in winter. He points to fields in that neighborhood fifteen years old and still in good condition. But if continually pastured, alfalfa in this region lasts but a few years, being crowded out by native grasses. These native grasses, says Señor Bab, will not sustain finely bred cattle, which deteriorate very rapidly and even die if given nothing else. Only native cattle can live on them, and even these will not fatten. The great heat in summer burns up the fine grasses; only alfalfa endures. The colonists under Señor Bab have found a sure and profitable business pasturing well-bred cattle on alfalfa. The carrying capacity there is estimated by the manager to average three-fourths of an animal per hectare (2.471 acres) on natural pastures, and on alfalfa five breeding animals or three for fattening. Of course this estimate is subject to great changes, according to the amount of rainfall.

Around Carcarañia, 30 miles west of Rosario, they have fields twenty-five years old, but the average is ten to fifteen years if cut, five to seven years if fed, and eight to nine years if fed and cut. This is about the average for the greater part of the alfalfa region, but of course varying conditions shorten or add to the life of alfalfa in different regions.

Little is done to prolong the life of alfalfa. Some farmers and ranchmen use disk harrows or plows in the spring with beneficial results. Some are of the opinion that this is of but little and only temporary benefit, and that it hardly pays. They say it is better and cheaper to let the alfalfa go to seed, resow itself, and then plow it. Others say that if they could get satisfactory disk harrows to cut 2 or 3 inches deep and not clog, such implements would be used with great benefit to alfalfa, starting new plants every spring, and would be generally used.

## CATTLE-CARRYING CAPACITY OF ALFALFA.

Alfalfa never does less than to double the carrying capacity of the native grasses of Argentina, however rich they may be, unless it happens to be in a locality where rock is too near the surface for alfalfa to do well. Generally it multiplies the carrying capacity three to six times. In southern Cordoba, Santa Fe, western Buenos Aires, San Luis, and other favored alfalfa regions, 3,000 cattle are now being fattened all the year around on every league (6,672 acres) of alfalfa, and another thousand, or even more, might be added if they were all

breeding cattle. Hitherto these camps would carry only about 800 animals per league, and give the animals barely enough vitality in the summer to carry them through the winter. The native grass there is called "pasto fuerte," which means tough grass; and so it is, wiry and thin. Cattle rarely get fat on it, and only the tough, undersized native cattle can live on it. Better bred stock deteriorate at once; so this region and thousands of leagues of Argentine territory would not be stocked with good cattle without alfalfa. In south central Buenos Aires, where the native grasses have nearly all been killed off by overstocking with sheep, the hard, worthless "pasto puña" has come on and the fine grasses have no chance. The carrying capacity of this land was 2,500 to 3,000 sheep per league, or 500 cattle, and they barely managed to keep alive. Now, under alfalfa, the same land carries 7,000 sheep or 1,200 cattle and keeps them in good condition the year around.

At the rate of one animal to 8⅓ acres, the usual average carrying capacity of native grasses, alfalfa makes land for grazing purposes worth five to eight times as much as it was before alfalfa took the place of the native grasses. Some native pasture (Pl. III) in the Province of Buenos Aires will carry one animal for every 2 acres, but of course nothing will stand dry seasons as alfalfa does. This was thoroughly proved in the dry, cold winter of 1902 in Argentina. Alfalfa pastures that seemed to be all dead made an astonishing recovery the following spring. Ordinarily when the native grasses have been entirely dried up alfalfa is still green and furnishing food for the animals, because of its deep-drawn water supply. Indeed, it is quite safe to say that alfalfa pasture is always worth two to two and a half times as much as the best combination of native summer and winter grasses. It is often said that a native grass called "gramilla," which comes with alfalfa, adds to its feeding value.

The carrying capacity of alfalfa pasture in Argentina is estimated at from two and a half to four animals per square (4.17 acres) the year around, or, in round numbers, from three-fifths to one animal per acre. An animal here always means a beef animal, and it is estimated that any pasture will usually carry four times as many sheep as it will cattle. This estimate is for breeding cattle. For fattening it must be reduced somewhat, but not much. Except in the winter alfalfa pasture will fatten three to five rough animals per square in five to eight months. Rough thin work oxen are fattened in this time. There is a large business in raising feeders on poorer lands north or south on native grasses and driving them in great troops to the alfalfa fields to be fattened. As the animals approach within a few months of the age at which they should start for market they are shifted about from one pasture to another and are given the best on the place. At other times they are not moved much, but are left in one large pasture sufficient for their needs for a year.

### WASTE OF ALFALFA AND OVERSTOCKING.

In the summer much alfalfa is allowed to go to waste because it is not always practicable to put more cattle on to fatten in the summer than can be carried through the winter. Some cutting of pastured alfalfa is often done. After the first spring growth has been eaten down the cattle are taken out for a few weeks and hay is put up, with a temporary fence built around the stacks. If the pasture gets poor in the winter, the fence is taken down and the cattle allowed to eat the hay in the stack. If not used during the winter, it may be sold in the spring. But this plan is not followed by all ranchmen. The ranchman (estanciero) is not always prepared to do much haying. He leaves that to the small farmer.

Overstocking is one of the weaknesses of the Argentine ranchman, though he is learning better through expensive lessons. When cattle were cheap and slaughtered for their hides it did not matter so much if a man lost a few thousand occasionally. He stocked his camp to the limit of its capacity at its best, and when a bad season came he lost half his stock or more. It often cost more to feed them than they were worth. Now, with valuable graded cattle they can not afford this. They have found by experience that alfalfa will be better in the winter and will live longer if it is not eaten down closely in the summer, but is permitted to grow to its full height.

## MAKING HAY OF ALFALFA.

Raising alfalfa for hay is a good business in Argentina, if the haul to the railway station is not too long. It is done mostly by small farmers, "chacareros," within 10 or 15 miles of railway stations, though occasionally large estancias do a big business in it when favorably located. On these great ranches, however, alfalfa is used chiefly for grazing, and only enough is cut for hay to supply home needs and guard against a dry, cold winter, when the pastures run down. Valuable breeding stock is fed dry alfalfa more or less the year round, though there is a growing demand for a good quality of bulls, "á corral"—that is, bred to the open field and able to run with the herd and take chances the year round.

### ADVANTAGES OF CUTTING AND GRAZING COMBINED.

There is little difference of opinion in Argentina about the advisability of cutting the surplus from alfalfa pastures in the summer. Unless double the number of animals are put on in the summer they can not eat the luxuriant crop that grows, and they waste it. "Theoretically," says Mr. Williams, in the south central part of the Province of Buenos Aires, "there is no reason why all the alfalfa should not be cut every year, but practically it is impossible to do so when dealing with thousands of hectares. It is much more economical to store it

for winter use by stacking than to allow it to grow into a tangled mass, which the cattle trample and spoil." Mr. John Benitz, of southern Cordoba, says: "Cutting improves alfalfa, allowing it to come up to its full height, which is life to it." He warns against the practice of stocking alfalfa to the limit in the summer time, saying: "Of course in the summer a great deal of the alfalfa goes to waste; but there is less risk of running short of feed in the winter, and it is this letting the alfalfa grow up to its full growth each summer that insures to it a great number of years of life."

Both these gentlemen have been very successful in their respective localities. Yet this system of grazing and one cutting is comparatively little followed in Argentina. Alfalfares are usually used altogether for hay or altogether for grazing. Only occasionally do ranchmen put up hay in the pasture with a fence around it, to be taken down in the winter to allow cattle to eat when they need it.

### YIELD AND PROFITS OF ALFALFA AS HAY.

The yield per acre varies greatly in different seasons and localities. In central, eastern, and southern Buenos Aires three or four cuttings per year are considered good, and it is the exception to get five cuttings. The amount secured varies from 1,500 to 3,000 pounds per acre, generally about a ton per cutting the country over.

In southern Cordoba, in a great part of the Province of Santa Fe, and in western Buenos Aires alfalfa grows more rapidly and the yield per acre is much greater. Four to eight cuttings are secured every summer, and five to six cuttings is the average in good seasons in the best regions. Four cuttings is the general average to be relied upon. If rainfall is abundant, more will be secured. If the summer is dry, there may be only three cuttings.

An estimate[a] of the cost of making alfalfa hay and its value in the Jewish colony at Mosesville, about 100 miles northwest of the city of Santa Fe, is given herewith, converted into United States terms and with values expressed in United States currency:

| | | |
|---|---|---|
| Price in stack, per ton | | $2.40 |
| Cost of cutting, per acre, with machine | $0.36 | |
| Raking, gathering, and stacking, per acre | .71 | |
| Cost per ton, at 1 ton per acre | | 1.07 |
| Net profit, per ton | | 1.33 |

Alfalfa in this region, for cutting exclusively, gives from five to eight cuttings per year. The average annual yield is better than 6½ tons per acre, so the farmer gets, in round numbers, from $6 to $10 per acre per year, or an average of $8.65 for the use of his land, horses, and machinery, all other expenses of the harvest being paid out of

[a] From the monthly "Anales" of the Argentine Rural Society for January, 1903. It corresponds very closely to an estimate made later by the manager of the colony.

FIG. 1.—TWO-YEAR OLD SHORTHORN HEIFERS IN ALFALFA, NORTHERN PART OF PROVINCE OF BUENOS AIRES.

FIG. 2.—STACK OF ALFALFA CONTAINING 100 TONS, 60 MILES FROM BUENOS AIRES. IN FRONT IS "TROJA," OR ARGENTINE CORN CRIB.

the cost estimate of $1.07 per acre, or per ton. Stock is never put on during the first year of growth there. They sow 23 to 27 pounds of seed per acre.

The cost of preparing for market or for export is given by the same authorities as follows:

| | Cost per ton. |
|---|---|
| Baling with machine | $1.60 |
| Wire | .30 |
| Hauling, 9 to 13 miles to station | .72 |
| Loading cars | .22 |
| Commission and various charges | .44 |
| Add price in stack | 2.40 |
| Cost baled | 5.68 |
| Freight to Santa Fe or Colastine, nearest river ports | 1.75 |
| Cost at the Parana River | 7.43 |

Prices in the Santa Fe and other upper-river markets at this time were about $9.50 per ton, leaving a handsome profit to the buyers. The freight to Buenos Aires from the station nearest the colony, to which the haul would not be over 5 or 6 miles, is a little over $4 per ton, and the distance is about 355 miles.

Much complaint is made of the high freight rates, which greatly retard the development of the hay industry. Prices in the Buenos Aires market were at this time and are now (December, 1903) about $12 to $13 a ton for the best alfalfa hay. During the winter of 1903, in the month of August, it was quoted there at from $15 to $19.25 per ton. The producers who had not previously sold their hay in the stack received much more than $2.40 a ton for it then. Prices are better toward spring, and are higher nearer the city of Buenos Aires. Jewish colonists are going more into alfalfa, corn, and stock raising, growing less wheat, which has proved a failure in this region in recent years. The Italian and other farmers in that part of the country have done likewise and profited well by it. Farmers who have stuck to wheat have brought poverty upon themselves, while those who have done mixed farming, with alfalfa and corn and stock to eat it, exhibit every indication of prosperity.

### LOSSES IN THE STACK.

Losses are sustained everywhere in the alfalfa hay business by the failure of the stacks to shed water. These losses are estimated at from 8 to 30 per cent of the total amount, depending upon how well the stack was made, how large it was, and how much rain fell. Sometimes in wet weather the outside of stacks to the depth of a yard must be thrown away when it is baled. This leads to large stacks, such as the one shown in the illustration (Pl. IV, fig. 2), which contains 100 tons and is well proportioned. Losses are also often suffered by rains coming on when the alfalfa is in the cock and ruining it altogether if the rain lasts any lenth of time.

### MARKETING AND MARKETS.

Bales for export weigh 50 kilograms, or 110 pounds, and are made in United States steam presses. Very large bales, weighing several hundred pounds, are made in hand presses for domestic use.

Alfalfa hay is an important article of export from Argentina, and the increase of this trade is predicted by Argentine authorities. It originated in 1864, when, during the war with Paraguay, Argentina was obliged to send alfalfa for the horses of the allies, Brazil, Uruguay, and Argentina. This led to a trade in alfalfa hay with Brazil, though it did not amount to much until about 1890, in which year about 22,000 tons were exported. The amounts exported annually since, with the average values of the export product, were as follows:[a]

*Exports of alfalfa from Argentina.*

| Year. | Tons. | Price per ton. | Year. | Tons. | Price per ton. | Year. | Tons. | Price per ton. |
|---|---|---|---|---|---|---|---|---|
| 1891 | 33,073 | $12.25 | 1895 | 79,320 | $5.26 | 1899 | 116,401 | $9.61 |
| 1892 | 43,220 | 8.36 | 1896 | 115,471 | 7.52 | 1900 | 113,356 | 10.91 |
| 1893 | 58,998 | 10.44 | 1897 | 114,908 | 7.88 | 1901 | 104,851 | 8.85 |
| 1894 | 52,489 | 8.39 | 1898 | 125,148 | 9.61 | 1902 | 108,208 | 8.95 |

These prices are about the average market prices for the years quoted in the Buenos Aires market. It is said that the reduction in the amount exported during 1901 and 1902 was due to the fact that the English ports were closed to Argentine live stock during those years on account of foot-and-mouth disease in Argentina. This operated, for various reasons, to interfere with the exportation of alfalfa to that market. The principal markets for hay from Argentina are Brazil, England, and South Africa.

### FEEDING ALFALFA HAY AND CORN.

Progressive cattlemen, almost without exception, as far as seen by the writer, are looking forward to the time when they must feed their steers with alfalfa hay and Indian corn to get the best results. The recent outbreak of foot-and-mouth disease in the country will check this movement somewhat, because it is likely to delay the reopening of the English ports to Argentine live stock. The animal sanitary law in Argentina is very thorough, and every effort is made to enforce it, to prevent the spread of the disease, and to exterminate it; but after the outbreak of 1900 seemed to have entirely disappeared it was about two years before the British Board of Agriculture would reopen the ports to Argentine live cattle and sheep. They remained closed from April, 1900, to February 3, 1903, and were again closed in May, 1903. It was thought that this would be only temporary, but the disease got out into the country and even made its appearance in

[a] Argentine custom-house statistics, reduced to avoirdupois tons, and prices per avoirdupois ton in United States currency.

the great annual expositions of breeding stock in Rosario and Buenos Aires in September and October, 1903. The disease, while quite general in extent, was mild in character and disappeared in a few months.

Advanced stockmen are very generally agreed now that it will pay them to finish their export animals on dry alfalfa and corn and to give them dry alfalfa in the winter time if the pastures run low. The great majority agree, except as to how long they should feed the animals before shipping. Opinions on this point vary from two to six months. They all know that cattle fed only on grass or alfalfa lose on a railway journey, and lose still more from the time they arrive at the port of export if they are to be exported alive. They are more or less wild, and they do not know how to eat the hay and corn which is given to them in the export yard and on board ship. Consequently heavy losses are suffered by the exporters, who become very cautious and cut down on the price of steers not trained to eat corn. This feeding has been done on a small scale already with very profitable results, but the high price of corn has discouraged it. Corn has been worth from 30 to 35 cents per bushel on the farm the past two years, and has sometimes been worth even more. Some of the more progressive ranchmen are planning to raise their own corn for feeding and do it in a more intelligent manner and get better results than the average small farmer.

### SUPERIORITY OF CORN-FED BEEF.

The proposition to feed dry alfalfa and corn has applied only to steers for export alive, but it is bound to be applied also to those destined for chilled beef, for experience is gradually teaching Argentine beef producers that a grass or alfalfa fed steer can not compete with a corn-fed steer. The latter will be sounder, more solid, and his carcass will cut up to much better advantage. The corn-fed beef is worth more to the pound, because it is firmer and has less water in it than that of animals fattened on green alfalfa or grass only. The increase in the number of chilled and frozen meat companies in Argentina is stimulating a demand among the first-named concerns for superior steers, and better prices are being paid. It is certain that they will pay more for corn-fed animals than for the soft alfalfa beeves. Whether or not they will pay enough more to warrant the expense of several months' feeding is not yet proved. But as soon as the English ports are open to Argentine live stock, feeding corn and dry alfalfa will be a general rule.

### GROWTH AND PROFITS OF CHILLED-BEEF TRADE.

The business of producing fat steers in Argentina has been subject to more fluctuations than in the United States, but is now approaching steadier conditions. Alfalfa has been the chief factor in removing the element of chance from the industry. Its intelligent use has taken

away every risk from starvation in dry, cold winters. It has increased the production of good cattle and made the future supply certain; so that more chilled-meat concerns are entering the field, making a better market. The chilled and frozen meat companies now operating in Argentina are as follows, with their daily capacity:

*Frozen-meat companies in Argentina.*

| Name. | Location. | Daily capacity. | |
|---|---|---|---|
| | | Steers. | Sheep. |
| Sansinena | Buenos Aires | 250 | 6,000 |
| Las Palmas | Zarate | 170 | 3,000 |
| Drabble Bros | Campana | 170 | 3,000 |
| La Blanca | Buenos Aires | 150 | 3,000 |
| Cold Storage Co | La Plata | 300 | 6,000 |
| Sansinena | Bahia Blanca | 150 | 3,000 |

One or two large chilled or frozen meat establishments will be completed soon in Rosario and one or two more in Buenos Aires. La Blanca and Sansinena at Bahia Blanca, listed above, are new. An American company has been organized to build one in Necochea, south of Buenos Aires, and it is understood this company will ship chilled meat to New York. Several other companies are being organized, as the older companies, the first three named, have been earning large dividends—from 20 to 40 per cent—while they controlled the market.

## PRICES OF CATTLE AND SHEEP.

The competition of the chilled-beef companies and the shortage of the supply in the winter and spring of 1903 (the months from June to November) stimulated the price of both cattle and sheep in Buenos Aires. When the English ports were closed, in May, 1903, good export steers—and the best were demanded for this trade—were selling at from $40 to $50 each. As soon as the ports were closed prices fell nearly 20 per cent on cattle, but not on sheep. In four months these prices were nearly restored, while prices for sheep had been going up for eighteen months, and fat wethers were selling at $5 to $6.50 down to $2.50 for common grades and $1.30 to $2.65 for lambs.[a]

## LATER CONDITIONS NOT SO FAVORABLE.

A decline in the price of sheep began in November, 1903, and continued until January, when the price began to recover slightly. The decline was about 33 per cent at its greatest, and in March, 1904, prices for the best types of mutton and lambs were still 20 to 25 per cent lower than they were in July or August, 1903; but were rising.

In December, 1903, the frigorificos suddenly reduced their operations. Some of them practically closed down for the time. The reason assigned was that the demand for Argentine chilled and frozen meat had fallen off in England, and that the prices of steers had

[a] In 1902 the average price of native sheep of 60 to 100 pounds weight in the Chicago market was $1.25 to $6.50, and for native yearlings and lambs $2 to $7.25.

advanced in Argentina until it was no longer profitable. The companies were making no profits. There had been a heavy decline in the market price of shares in the Argentine freezing companies. The result of this action was an immediate drop of from 15 to 25 per cent in the price of steers. There has been but little recovery in this price up to the 1st of March, 1904. When the cooler weather begins work in the freezing plants is resumed and prices of steers and sheep improve. A large number of fat young steers are ready to be placed upon the market there. Exporters, stockmen, and Government officials are endeavoring to find an outlet for this production. A shipment of Argentine chilled meat was rejected in Austria on some hygienic ground, but it is claimed by the Argentines that it was done because of the opposition of the agrarian interests. Argentines have been shipping some chilled meat and some live animals to other European ports during the past year, including Hamburg, Lisbon, and some of the Spanish ports. They are striving hard to develop a market on the continent of Europe for their various meat products, and are meeting with some success.

Steers come to market now usually about three years old, and this is a gain over former years, due to alfalfa. Formerly weight counted more than quality, and steers were kept on grass till they were four or five years old. Now the lighter, young beef is preferred, as in this country. The favorite weights are 1,200 to 1,400 pounds.

Feeders, about two years old or a little more and very thin, are bought for $9 or $10 per head, put on alfalfa pasture for six to ten months, and sold for $30 to $40. A good business is done by a few estancieros in buying up old work oxen in exceedingly poor condition, paying $13 to $15.50 for them, putting them on alfalfa for six to eight months, and selling them for from $24 to $30. Fairly good grade steers, three years old, fattened on alfalfa pastures, are now selling for $40 to $48 in the country stations in Argentina, and it costs $4 or $5 per head to get them to the slaughtering places in the ports. This does not include the taxes on sales that are levied in some of the provinces nor the taxes levied by the municipalities where the slaughtering is done. These taxes vary, but will amount to several dollars more. Nearly all of this type go to the "frigorificos," or chilled and frozen meat institutions, for export.

### UNITED STATES BEEF TRADE AS COMPARED WITH ARGENTINE.

Very briefly stated, for comparison, the business of exporting steers from the United States is carried on about as follows: Good grade steers are procured, either from farther west or at home, and are fed mostly in the central corn States for Chicago, where most of them are shipped. Feeding to fatten usually begins at the age of from sixteen to twenty months and lasts from three to six months. Then they are shipped to Chicago to be sold. Freight rates range from 18½ to 35½ cents per 100 pounds in carload lots from the feeding places to Chi-

cago. From Nebraska points the rate is 30½ to 35½ cents; from Missouri and Iowa points the rates are usually about 22 to 23½ cents, though a few points have as low a rate as 18½ to 19 cents; Kansas rates are 32½ to 37½ cents, with but few shipments to Chicago; rates in the State of Illinois vary greatly, but are much lower than Iowa or Missouri rates. In the Chicago Stock Yards these animals pay 50 cents each commission charge and 25 cents each yardage. They must also pay for feed, but if they are shipped east for export on the day of arrival this is very small. In the Chicago yards steers are sorted for local slaughter, export, or eastern markets. Comparatively light young steers, weighing from 1,175 to 1,300 pounds, are wanted for export, and these sell from $4.40 to $6 per 100 pounds, live weight, though of course these prices vary widely at different times. The best steers, the special young "baby beeves," that bring the highest prices, are not exported, but are reserved for fancy beef in the large city markets. The export steers are, however, of a superior quality. Prices in December, 1903, in the Chicago market were: Low-grade export steers, $4.40 to $4.70; good export steers, $4.70 to $5.15, and for prime fat beeves of 1,175 to 1,300 pounds weight, $5.15 to $5.50. The freight from Chicago to New York is 28 cents per 100 pounds, live weight. If loading on shipboard is prompt, charges in New York are light, not more than in Chicago. The ocean freight rates to English ports are from 30 to 35 shillings ($7.30 to $8.50) per head. Insurance is one-half of 1 per cent, and steers are insured for $50 per head, except "distillers"—those fed on distillery waste—which are valued at $75 each.

No charge is made for the inspection by the United States Bureau of Animal Industry at the Chicago Stock Yards and at the port of export. Every animal is tagged and numbered, so his identity is never lost, and the record is so complete that if it becomes necessary the animal can be traced from the English slaughterhouse back to the farm on which he was raised or fattened. This record is sent to the Bureau of Animal Industry inspector in the foreign cattle market at Deptford, near London, whose business it is to watch the results of the slaughter of steers from the United States and report by cable the tag number of any animal showing any disease that requires investigation. The matter is promptly followed up from this end, so that quarantine or other precautionary measures may be taken if necessary. These precautions are taken by the United States Government for the protection of the cattle trade, to make certain that every animal, as well as the chilled beef exported, is in perfect condition and the accommodations on shipboard are of the most approved kind.[a]

[a] The Argentine Bureau of Animal Industry inspects all cattle that are to be exported, first on the ranch before they are shipped and afterwards at the port of export. Inspectors are also stationed in all the chilled and frozen meat establishments and in the city slaughterhouses, to see that no diseased animals are used for food.

## FINE CATTLE OF ARGENTINA IN SHOW AND AUCTION.

### FAT STOCK SHOW OF 1903.

In May the Argentine Rural Society gives a fat stock and horse show, to which, for the first time, in 1903, was added an exposition of agricultural products. There is generally a lively competition for the championship in the fat steer class, though there is no such scientific feeding competition, exemplified in a single animal, as we have every year in the International Live-Stock Exposition in Chicago. The entries are made in lots of 8 animals, and while they are fed for exhibition, they are prepared under conditions approaching the normal, or what the average, progressive ranchman might do if he chose. These expositions have a positive influence upon beef production in the country, showing what may be done by breeding and feeding.

#### PRIZE WINNERS.

One man exhibited 9 lots of 8 animals each in the last show, and took first, second, and third prizes in a competition of 26 lots. All the prize winners were pure white well-bred Shorthorns, and so were most of the 72 animals shown by this breeder, Dr. Benito Villanueva, who is the presiding officer of the lower house of the Argentine Congress. The prize lot averaged 2,145 pounds each when they were weighed on the show grounds, and the exhibitor claims they had lost about 60 pounds each after they left his estancia, distant about 194 miles by rail. Of course these animals were tame, having been much handled and sheltered, so they lost less in transit than the average Argentine steer. These were born in January and February, 1898. This class was for steers of three, four, and five years, and most of them were from four to five. All of Doctor Villanueva's steers were dehorned, a practice in which he thoroughly believes, though it is not generally practiced in Argentina. Doctor Villanueva's manager, who prepared these animals for the show, told me that he took them off alfalfa pasture and fed them on corn and dry alfalfa and gave them shelter when necessary for ten months before the show. Part of the time they had the run of the alfalfa pasture also. These animals made a beautiful showing in the parade and overcame the prejudice of many breeders against white coats. This objection has been and is yet very strong among Argentine breeders. An incident in the pedigreed-stock show of last October confirmed it. A white bull won one of the principal first prizes, but in the sale that followed he sold for less than one-third the price of several others of his class, less than half the price of many, and was sold, in fact, for a very low price, though the only objection to him was his color.

The prize lot of fat steers was presented by its owner to the Chilean delegation, at that time on its official peace jubilee visit to Buenos Aires, and the animals were slaughtered, and the beef used on board the Chilean naval vessels then in the Buenos Aires docks.

AUCTION SALES.

The sales at auction of fat steers, held on the grounds, were very unsatisfactory to the exhibitors. Exportation on the hoof had been stopped by an outbreak of foot-and-mouth disease a few days before, and the "frigorificos" (frozen and chilled meat companies) evidently had an understanding among themselves not to pay the high prices which they had paid the year before. As these companies offer the only market for good steers, they have the producers at their mercy when they can agree. A few representative sales are given herewith, showing weights per animal in pounds, with prices per animal in United States currency:

| *Shorthorns.* | | | | *Polled Angus.* | | *Flemish.* | |
|---|---|---|---|---|---|---|---|
| Weight. | Price. | Weight. | Price. | Weight. | Price. | Weight. | Price. |
| 1,648 | $53 | 1,607 | $57 | 1,261 | $37 | 1,431 | $40 |
| 1,865 | 75 | 1,561 | 48 | 1,380 | 48 | 1,402 | 40 |
| 2,070 | 75 | 1,925 | 75 | 1,501 | 48 | 1,312 | 37 |
| 1,874 | 57 | | | 1,435 | 44 | | |

FAT STEERS FOR SALE ONLY.

In this class 31 lots of 8 animals each were shown, all but one being Shorthorns and Shorthorn grades. This one group, weight 1,407 pounds each, was a Shorthorn-Polled Angus cross. Some of the weights and sales follow:

*Shorthorns and Angus grades.*

| Weight. | Price. | Weight. | Price. | Weight. | Price. |
|---|---|---|---|---|---|
| 1,285 | $37 | 1,753 | $53 | 1,407 | $48 |
| 1,349 | 37 | 1,570 | 48 | 1,543 | 53 |
| 1,519 | 40 | 1,594 | 48 | 1,587 | 53 |
| 1,949 | 53 | 1,495 | 48 | | |

FAT COWS AND STEERS.

Twelve lots of fat cows were entered for prizes in a class admitting any age or breed. Two of the sales (Shorthorns) were: Weight, 1,521 pounds; price, $37. Weight, 1,517 pounds; price, $37.

The Polled Angus steers, of which six lots, 48 animals, were shown, made a very good impression. They were three and four years old, and, though lighter than the prize-competing Shorthorns, brought better prices in proportion to their weight, as the lighter-weight grade Shorthorns did also. Three lots, representing a cross of Flemish and Shorthorn, made fairly acceptable weights, but brought moderate prices. The Herefords, which up to 1901 had taken the championship in the fat-steer class, were not represented in any way. The Hereford does not seem to be gaining ground in Argentina, as the Polled Durham notably is and the Polled Angus to some extent.

SHEEP, HORSES, AND POULTRY.

The showing of sheep (Pl. V) was small. Two groups of Lincolns and three of "Black Faces" (Hampshire Downs), each of 40 animals, completed the sheep exhibit. The prize Lincolns, averaging 176

FIG. 1.—SHEEP IN THE PARK OF THE ESTANCIA SAN JUAN, PROPERTY OF DON LEONARDO PEREYRA, NEAR BUENOS AIRES.

FIG. 2.—PURE BRED DURHAM COWS ON PEREYRA ESTANCIA, NEAR BUENOS AIRES.

pounds, sold for an average of $4.84 each. The "Black Faces," though much lighter in weight, sold for about the same.

The horse show, though not large, brought out some very good roadsters and saddle horses. The prices realized in the sales were not high, but a little above those in the show of the previous September.

Interest in poultry was shown by good exhibits of Dorkings, Plymouth Rocks, Light Brahmas, etc. A few ducks and turkeys were exhibited.

Not a pig was to be seen in the show.

### HIGH PRICES FOR BREEDING ANIMALS.

The demand for the best Shorthorn blood is increasing in Argentina, and it is a better market for good young bulls than ever before. Every ranchman is trying to improve the standard of his herd, culling out the undesirable cows, getting as good bulls as he can afford to buy, and preparing to give his cattle alfalfa pasture, if not to finish them with corn and dry alfalfa. The aim of everyone is to produce steers for export, either alive or as chilled beef. This has multiplied the requirements of the country for breeding stock. There is no indication of a decrease in the demand, but rather of an increase, for the planting of alfalfa is more than doubling the carrying capacity of Argentine grazing land, while the building of new "frigorificos" insures better prices because of competition.

Dr. E. Ramos Mexia, president of the Argentine National Rural Society, expressed the opinion, in his address upon the opening of the annual show in September, 1903, that exportation of cattle alive from Argentina was an unstable business that could never compete with the "frigorificos." "With one-fourth the cost of transportation," he said, "chilled meat brings the same price as that sent on the hoof." The losses suffered by those engaged in shipping live steers from Argentina to England from February to May, 1903, when English ports were open to Argentine live stock, and the high prices for both steers and sheep prevailing since the English ports were closed to Argentina, are facts cited by Dr. Ramos Mexia in support of his statement.

### SALES OF SHORTHORN BULLS.

In an auction sale in Buenos Aires November 4, 1903, a Shorthorn bull from the herd of William Duthie, just imported, was sold to Don Gregorio Villafañe, who is the leading Hereford breeder of the country, for $7,260, the highest price ever paid for a bull in Argentina. Others in the same lot were sold for $3,960, $3,080, $1,760, and so on, the lowest being $880, and the average for the nine being $2,479. Several other sales of English, Scotch, and Irish bulls were held in Buenos Aires during September and October, when the prices were from $700 to $3,500, and probably about 150 imported animals were

sold at these prices. These sales have continued at short intervals since that time, and high prices have always been realized for Shorthorns imported from England.

### PRICES AT NATIONAL LIVE-STOCK SHOW.

At the time of the National Live Stock Show in Buenos Aires in September and October, 1902,[a] the opinion was quite general that the prices then paid for breeding animals raised in the country would not be maintained another year. Both breeders and auctioneers said so. But, on the contrary, the sales at the recent show in September and October, 1903, brought better prices than in 1902, and under very discouraging circumstances. Foot-and-mouth disease had broken out in the show itself, as it was prevalent in the country. It is stated that 40 per cent of the animals on exhibition had the disease. Many animals were sold when they were actually afflicted, but it does not seem to have discouraged the payment of good prices. The disease is said to have been in a mild form, and but very few animals died. Those kept in pens in the open air were much less affected than those in stalls and, if they did take the disease, fell away much less than the carefully prepared show animals in the sheds. Animals brought up in the open field showed more vitality, and this is one reason for the high prices obtained for grade bulls bred in the open, without shelter. The average price paid for all Shorthorn bulls, pedigreed and grade, field bred and stable bred, in 1902 was $372. In 1903 the average price of 483 Shorthorn bulls of all grades sold by one auction house was $595. The total sales of breeding stock in this show were $668,404, of which this house sold $408,544, or more than 61 per cent, so the average of its sales is not far from the average for the entire show. The sales of 1903 exceeded those of 1902 by $100,013, or nearly 18 per cent, though the number of entries was smaller. Every animal shown or sold in this show was born in Argentina, for this was a national show, and no animals except those bred in the country could be shown or sold on the grounds. This year's show, in September and October, 1904, may be an international show, when imported animals may be entered for prizes and for sale.

## BREEDING-STOCK SHOW.

### ENTRIES OF CATTLE, HORSES, AND SHEEP.

The entries in the breeding-stock show of September and October, 1903, were as follows:

*Shorthorns.*

| | |
|---|---|
| Registered bulls | 243 |
| Registered bulls for sale only | 184 |
| Grade bulls | 1,017 |
| Registered cows | 61 |

[a] See "The animal industry of Argentina," by Frank W. Bicknell, Bulletin No. 48, Bureau of Animal Industry, U. S. Department of Agriculture.

| | |
|---|---|
| Grade cows | 360 |
| Registered Polled Durham bulls | 7 |
| Registered Polled Durham cows | 5 |
| Total Shorthorns | 1,877 |

*Herefords.*

| | |
|---|---|
| Registered bulls | 47 |
| Registered bulls for sale only | 27 |
| Grade bulls | 39 |
| Registered cows | 28 |
| Grade cows | 34 |
| Total Herefords | 175 |

*Other breeds.*

| | |
|---|---|
| Registered Polled Angus bulls | 3 |
| Registered Holstein and Flemish bulls | 25 |
| Grade Polled Angus, Holstein and Flemish bulls | 32 |
| Total | 60 |

Total cattle, 2,112.

*Horses.*

| | |
|---|---|
| Stallions: | |
| Riding | 12 |
| Light driving | 56 |
| Heavy | 54 |
| Light and heavy road, for sale only | 48 |
| Camp mares | 90 |
| Total horses | 260 |

*Sheep.*

| | |
|---|---|
| Merino rams | 335 |
| Merino ewes | 80 |
| Lincoln rams | 275 |
| Lincoln ewes | 100 |
| Southdown and Shropshire Down rams | 40 |
| Southdown and Shropshire Down ewes | 20 |
| Oxfordshire Down rams | 30 |
| Oxfordshire Down ewes | 20 |
| Hampshire Down rams | 40 |
| Hampshire Down ewes | 20 |
| For sale only: | |
| Rambouillet rams | 121 |
| Rambouillet ewes | 50 |
| Lincoln rams | 188 |
| Lincoln ewes | 12 |
| Oxfordshire Down rams | 10 |
| Oxfordshire Down ewes | 20 |
| Hampshire Down rams | 30 |
| Total sheep | 1,391 |

PRIZE WINNERS AND PRICES.

The sales of prize winners in the pedigreed Shorthorn classes were as follows:

*Born March 1 to December 31, 1900.*—First prize and championship to Ladas 6th, red and white, born September 27, 1900, sold for $4,840; second, a roan, sold last year for $4,400; third, a roan, sold for $2,508; fourth, a roan, sold for $2,508. In this class there were 41 entries and 25 sales, at an average of $1,466; the lowest was $396 and the highest $4,840.

*Born January 1 to June 30, 1901.*—First prize, red and white, sold for $1,848; second, roan, $1,364; third, roan, $1,320; fourth, red and white, $1,320. There were 45 entries, 34 sales, and the average was $1,195 each; the highest was $2,728 and the lowest $352. Eleven bulls of this class were sold for $1,140 or more each.

*Born July 1 to December 31, 1901.*—First, a white bull that sold for only $748; second, roan, $2,288; third, red and white, $2,640; fourth, red, $748. There were 91 entries and 57 sales, the average being $1,088; the highest was $4,840 and the lowest $396. Twelve were sold for prices above $1,540.

*Born January 1 to June 30, 1902.*—First, not sold; second, roan, $2,640; third, not for sale; fourth, red and white, $506. There were 20 entries and but 6 sales, as most of these young bulls are reserved for the next year's sales. The highest price paid was $2,640 and the lowest $418.

AUCTION SALES OF CATTLE, HORSES, SHEEP, AND HOGS.

Details covering about two-thirds of all the animals sold in the show indicate the general character of the whole, all sales being at auction. These sales, amounting to $408,544 in United States currency, were as follows:

| Number and kind of animals sold. | Amount of sales. | Prices per animal. | | |
|---|---|---|---|---|
| | | Average. | Highest. | Lowest. |
| Pedigreed cattle: | | | | |
| 198 Shorthorn bulls | $186,175 | $940 | $4,840 | $286 |
| 10 Hereford bulls | 4,777 | 477 | 1,320 | 264 |
| 4 Flemish bulls | 1,826 | 456 | 660 | 264 |
| Grade cattle: | | | | |
| 285 Shorthorn bulls | 101,409 | 356 | 1,650 | 53 |
| 16 Hereford bulls | 1,760 | 110 | 137 | 53 |
| 93 cows and heifers | 9,750 | 105 | 286 | 26 |
| Pure bred horses: | | | | |
| 10 Clydesdale stallions | 6,820 | 682 | 1,342 | 264 |
| 9 Hackney stallions | 4,576 | 508 | 1,430 | 264 |
| 2 Anglo-Norman stallions | 668 | 334 | 334 | 334 |
| 13 Percheron stallions | 9,328 | 718 | 1,364 | 374 |
| 8 Shire stallions | 4,288 | 536 | 748 | 308 |
| 9 Yorkshire stallions | 3,190 | 354 | 484 | 220 |
| 2 Hackney ponies | 228 | 114 | 114 | 114 |
| 6 Hackney mares | 2,028 | 338 | 396 | 242 |
| Grade mares: | | | | |
| 16 cart mares | 1,120 | 70 | ..... | ..... |
| 8 coaching mares | 440 | 55 | ..... | ..... |
| 36 Clydesdales | 4,356 | 121 | ..... | ..... |
| 12 coaching mares | 552 | 46 | ..... | ..... |
| 8 Hackney mares | 352 | 44 | ..... | ..... |
| 6 female asses | 158 | 26 | ..... | ..... |

| Number and kind of animals sold. | Amount of sales. | Prices per animal. | | |
|---|---|---|---|---|
| | | Average. | Highest. | Lowest. |
| Sheep: | | | | |
| 217 Merino rams | $41,996 | $194 | $1,760 | $15 |
| 25 Merino ewes | 352 | 14 | 18 | 13 |
| 142 Lincoln rams | 17,318 | 122 | 1,056 | 44 |
| 18 Hampshire rams | 1,848 | 103 | 264 | 75 |
| 30 Hampshire ewes | 858 | 29 | | |
| 1 Shropshire ram | 75 | | | |
| 5 Shropshire ewes | 286 | 57 | | |
| 15 Oxfordshire Down rams | 1,553 | 104 | 154 | 4 |
| Hogs: | | | | |
| 4 male and 4 female Yorkshires | 680 | 85 | 101 | 79 |
| 3 Berkshire boars | 123 | 41 | 44 | 40 |

A new ruling of the Rural Society requires the auctioneers to collect their commission of 6 per cent from the buyers, who pay cash, and the auctioneers must pay 2 per cent of their commissions to the society. Auctioneers' commissions are now always paid by purchasers.

Herefords and Polled Angus were rather poorly represented, and prices, it will be noticed, were far below those obtained for Shorthorns.

One breeder sold 26 young pedigreed Shorthorn bulls for an average of $1,310 each. Another sold 24 "camp" bulls, with which no special pains had been taken, for $924 each. Several other breeders did nearly as well with Shorthorns. The sales were all extremely satisfactory.

The development of the dairy interest continues, and the exhibits and attention paid to this department by the people excelled the previous year. The demand for dairy machinery and appliances is very active.

The popularity of the Merinos is also shown by the sales. The average price for Rambouillet rams in 1902 was $159, while this year (1903) it was $194. One ram sold for $1,760 and another for $1,408. The former is the highest price ever paid for a ram born in the country. The highest price the previous year was $880. The lot of 10 to which the two mentioned belonged averaged $422 each. The sire of these rams was imported from Germany in 1900 and sold for $2,464. In 1903 335 Rambouillet rams were shown, against 304 the previous year. In Lincolns 832 rams were shown in 1902, and only 463 in 1903. The average price in 1902 was $99, and in 1903 the average of one auctioneer was $122, the higher prices being no doubt due to the smaller number offered. The champion Lincoln ram in 1902 sold for $704, and in 1903 the champion brought $1,056 and another one $880. In January, 1904, a Lincoln ram lamb, bred in the country, sold for $4,600 paper ($2,024 United States money), the highest price ever paid for a native Lincoln ram in Argentina.

Horse sales were about the same as in 1902, but prices were slightly better for the best of the draft animals and for the light roadsters, but lower for the common "camp" mares.

A few pigs were offered, but most of the classes were without entries

IMPORTS OF BREEDING STOCK.

Imports of pedigreed stock into Argentina for breeding purposes have been as follows since 1896:

*Annual imports of animals by classes.*

| Year. | Cattle. | Sheep. | Horses. | Asses. | Pigs. |
|---|---|---|---|---|---|
| 1896 | 988 | 7,305 | 163 | 116 | 105 |
| 1897 | 916 | 7,309 | 184 | 71 | 25 |
| 1898 | 623 | 6,962 | 154 | 31 | 2 |
| 1899 | 1,561 | 4,839 | 129 | 7 | 19 |
| 1900 | 998 | 9,165 | 208 | 74 | 3 |
| 1901 | 26 | 154 | 441 | 15 | ..... |
| 1902 | 64 | 272 | 30 | ..... | 5 |
| 1903 | 653 | 1,877 | 51 | 22 | 19 |

The classification of the principal breeds was as follows:

*Imports of cattle by breeds.*

| Breeds. | 1899. | 1900. | 1901. | 1902. | 1903. |
|---|---|---|---|---|---|
| Durham | 502 | 300 | ..... | 32 | 572 |
| Hereford | 46 | 14 | ..... | 6 | 31 |
| Polled Angus | 25 | 6 | ..... | 4 | 38 |
| Red Shorthorn | 314 | 118 | ..... | 7 | ..... |

*Imports of sheep by breeds.*

| Breeds. | 1899. | 1900. | 1901. | 1902. | 1903. |
|---|---|---|---|---|---|
| Lincoln | 3,597 | 1,869 | ..... | 271 | 1,179 |
| Rambouillet | 485 | 269 | 61 | ..... | ..... |
| Hampshiredown | 381 | 64 | ..... | ..... | 253 |
| Shropshire | 284 | 123 | ..... | ..... | 299 |
| Oxford | 103 | 50 | ..... | ..... | 44 |
| Romney | ..... | 38 | ..... | ..... | 71 |
| Leicester | 30 | ..... | ..... | ..... | 25 |

These statistics were prepared by the Bureau of Statistics of the Argentine Department of Agriculture.

## HANDLING CATTLE IN THE "BRÉTE."

While there are many wild cattle in Argentina that have never felt the civilizing influence of improved blood or modern treatment, these are not the ones with which the world's beef markets are concerned. The best steers are mostly unfamiliar with any feed but grass and alfalfa and are provided with no shelter, but they are more or less tame. They are not the wild, racing creatures we have read about

and seen pictured in the geographies. The well-managed estancia has its cattle well in hand, keeping close account of them and handling them frequently, so they become more or less tractable. They are often sorted and separated into different lots for feeding on different pastures for market at different times. Then there is the branding, the vaccination for anthrax, the castration, sometimes the trimming or removing of horns, and various other operations. All these things, if properly done, teach the animals not to fear being handled and make them better travelers when they go to market by rail or sea, or both. This training, when supplemented by a little feeding on dry alfalfa and corn, gives the steer raised by modern methods an immense advantage over the wild animals that find their way to Buenos Aires, especially if destined to go on board ship for transportation to markets over seas.

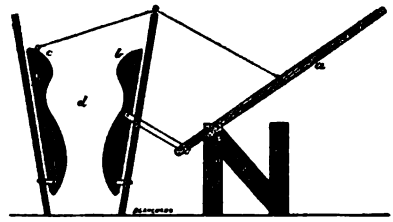

FIG. 1.—The yoke of the bréte. This yoke is placed inside the framework of the narrow chute, at the end nearest the scale. When the animal, released from behind, puts his head through the opening *d*, the man stationed at the lever, *a*, quickly pushes it down. This action closes the arms of the yoke, *c* and *b*, upon the animal's neck. The lever pushes the arm *b* and, by means of the wire running from the arm *c* over the top of the bréte to the lever *a*, pulls that arm, so they close quickly and simultaneously. After the desired operation is performed upon the animal, the lever is thrown up and he is released. The triangular swing gate is swung to permit the animal to pass to the scale or to the paddock, as desired. After he is weighed, the gate at the end of the scale may be adjusted to turn the animal either way, to the right or left, and in this way they are sorted. On the other side of the bréte, behind the yoke, is another lever, similar to the one shown above, by which the animal may be held more closely by having an adjustable board pressed firmly against him, forcing him against the operating side of the chute, where he is already held by his head, or neck.

The wild creatures wear themselves out trying to break away. They are in abject terror of everything near them, for they have never been restrained in any way before. Everything is new, and they do not understand that they will not be hurt, as the better trained animals do. They have never seen any dry food, and for days they do not eat. In the meantime the corral-broken animals are not losing, but are eating all they can get, including the portions of their frightened companions, and are gaining flesh from the moment they are unloaded from the trains that bring them to Buenos Aires. They are accustomed to being handled in close quarters from their calfhood, and they fear nothing.

The most necessary handling of the wilder steers was formerly done by means of a long rope lassoed around the animal's horns and passed around two upright revolving posts. The animal was then dragged to the posts by a horse and held there with much difficulty and more or less brutality while any necessary operation was performed. Naturally this does not tend to quiet the animal's fears or make him tame. It is

still done on some of the old native estancias, where modern methods have not been adopted, and the only question asked about a bull is whether or not he is capable of performing his function. But the

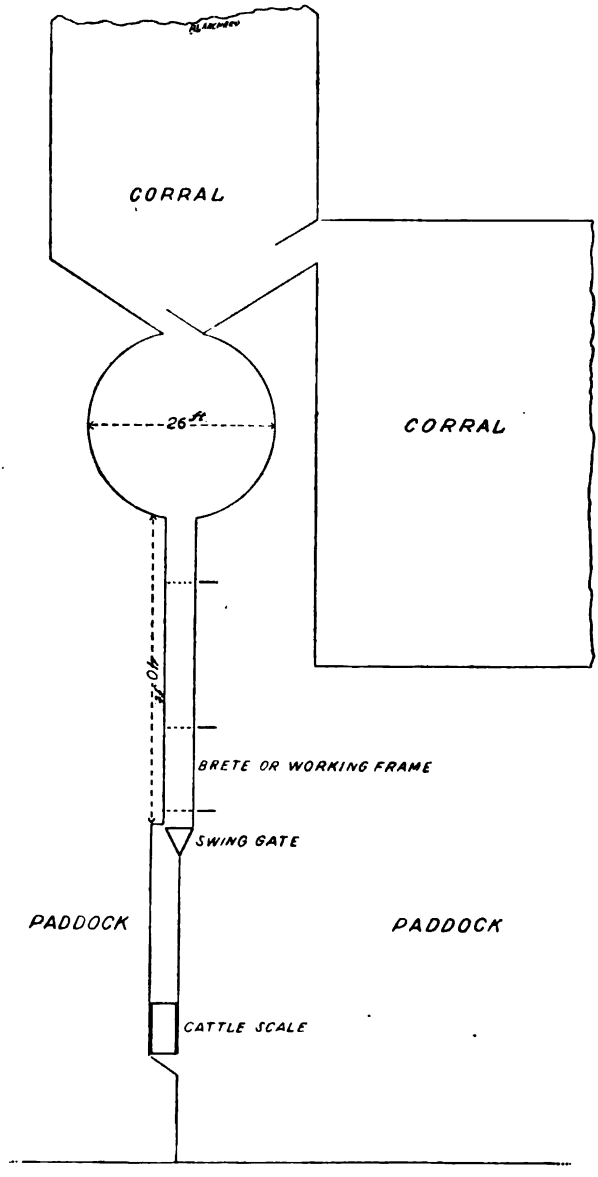


FIG. 2.—Ground plan of the bréte.

more progressive, and hence more successful, estancias have adopted an idea which came from Australia and has proved of great value where large numbers of cattle are to be handled frequently.

FIG. 1.—CORRALS LEADING INTO BRÉTE.

FIG. 2.—WORKING SIDE OF BRÉTE.

FIG. 3.—BACK SIDE OF BRÉTE.

## DESCRIPTION OF THE BRÉTE.

This improved method or apparatus is called a bréte (Pl. VI), and it is a simple piece of stout framework which may be made by any farmer if he will give it a little study and get the right materials. Briefly, it is a long chute opening out of a small round corral, and that from a larger one by a gate 12 feet long. This chute is just wide enough for one animal to pass, so he can not turn back or crowd ahead. It has crossbars worked with levers at several places to hold the animals and prevent them from backing out. At one place there is a working frame, where the animal is held securely in the embrace of a yoke (fig. 1) which closes in upon his neck, and any sort of operation may be performed upon him with perfect ease and without unnecessarily hurting the animal or allowing him to hurt himself. Thence he goes to the scales to be weighed, or, if not desired to weigh him, he passes by an adjustable gate into whichever corral his presence is desired. This is a rapid, easy, effective, and humane process, and the expense of building the bréte is not great. Many estancieros make a practice of putting their cattle through it often, so they will be accustomed to being handled. They say it makes them less wild, and they do less running in the pastures.

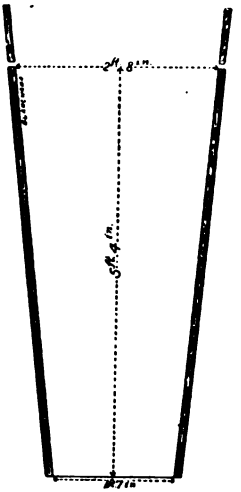

FIG. 3.—Section of the bréte, hardwood posts 6 by 6 inches, sunk 3 feet 6 inches in the ground.

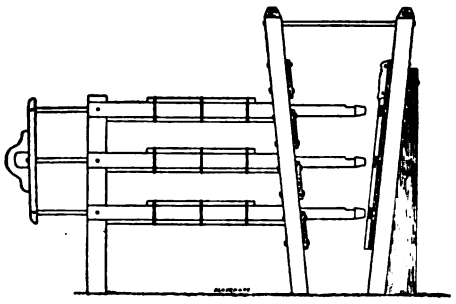

FIG. 4.—End view of bréte with closing bars.

A ground plan of a model bréte on the Estancia Victoria, near Carcarañia, the property of Mr. Henry B. Coffin, a progressive North American breeder, is given herewith, together with some illustrations (figs. 2, 3, 4, and 5) showing how the details are arranged and how the apparatus is operated. The dimensions are given, so that construction may be made from this plan. The whole shows a very

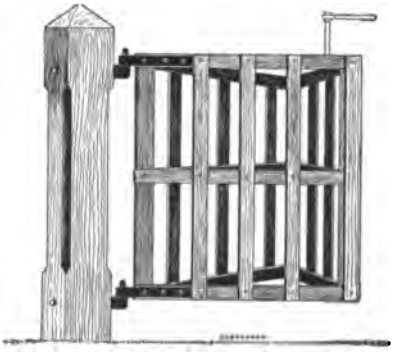

FIG. 5.—Triangular gate at end of the bréte.

conveniently arranged system of corrales for the handling of large numbers of stock where classification is desirable, and this classification is regarded as an important feature of estancia management in Argentina. The woodwork of the bréte should be of strong, straight-grained hard wood, well put together with bolts and iron braces, especially the bréte itself, or working frame, where the animal is handled, so its operation will be certain and quick, with no chance for it to get out of shape.

### DEHORNING IN THE BRÉTE.

Dehorning may be done in the bréte better than in any other way, but comparatively little of it is done in the country. The practice is more likely to be that of applying acid to the embryonic horns of calves, if the breeder thinks it worth while to get rid of horns. Many do not see the advantages of hornless cattle and claim that steers can be handled on shipboard better with horns than without. A steer without horns will bring a little more than one that has them, however. Three or four more cattle can be put into a car if they are without horns. They travel in better condition, and the difference in the hides is quite noticeable. The advocates of dehorning are increasing and so is the interest in the hornless breeds, particularly Polled Durhams. The prize fat steers shown in May, 1903, by Dr. Benito Villanueva, were all without horns, and his firm belief in the policy of dehorning has had quite an influence.

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U. S. DEPARTMENT OF AGRICULTURE.

Report No. 79.

# REPORT

OF THE

# SECRETARY OF AGRICULTURE.

## 1904.

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GOVERNMENT PRINTING OFFICE.
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HEINRICH HASSELBRING

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# REPORT

OF THE

# SECRETARY OF AGRICULTURE.

To THE PRESIDENT:

I have the honor to submit herewith my Eighth Annual Report as Secretary of Agriculture.

## INTRODUCTORY.

Since my last report progress has been made in securing cooperation with the experiment stations of the several States and Territories; some of the Bureaus of the Department make research in conjunction with all the stations. Preliminary steps have been taken to conduct feeding and breeding experiments in several States looking to the development of breeds of animals suitable to our conditions of climate and soils, and capable of meeting the demands of commerce at home and abroad.

Emergencies arising through the invasion of the cotton-growing States by the boll weevil, a Central American insect that has done much damage in Texas and threatens the entire cotton-growing section of our country, have been met by vigorous work that promises to enable the planters to grow crops in defiance of the pest. The spread over several of the mountain States of a cattle mange required vigorous intervention by the Department. It was necessary to detail a large force of experts to supervise the dipping of the herds in order to eradicate the parasite. Cooperation with most of the States has been arranged, and the rest promise to secure State legislation to compel all flock and herd masters to clean their stock.

The demand in the States for experts to supervise the building of roads suggests the education of engineers in the road laboratory for that work.

The efforts of the Department to create a hardy orange tree that would produce a sweet orange have at last been successful. A hybrid of the Florida orange and Japanese trifoliata has fruited and given us the desired result. Another hybrid gives us an orange very similar to the grape fruit, and a third gives us a fruit equal to the lemon for all practical purposes. Other fruits of these hybrids will be valuable for marmalades and cooking.

Valuable research has been made in fruit shipping to foreign countries; the value of promptly placing fruit in low temperatures as soon as it is taken from the tree is demonstrated.

The value of nitrogen-fixing bacteria has been thoroughly proved, greatly increasing yields of leguminous plants and the accompanying production of nitrogen in the soil.

Progress is being made in introducing plants that succeed in light rainfall localities.

Importers of foods and drinks are obeying the law with regard to adulterations and false labeling.

The elements of agricultural science are gradually finding their place in the primary and secondary schools, through the instruction of teachers.

We buy over $200,000,000 worth of products from tropical countries that can not be grown in continental United States. Through scientists sent from the United States to the several island groups the Department is instructing the people of our island possessions to grow these things, such as coffee, rubber, fibers, drug plants, nuts, fruits, spices, and the like.

Our farmers buy $100,000,000 worth of machinery every year. A better knowledge of its use and care is necessary. Several agricultural colleges are taking up this inquiry, and giving instruction in regard to machinery and farm buildings.

## AGRICULTURE AS A SOURCE OF NATIONAL WEALTH.

Favored with continued prosperity in 1904, the farming element of the people has laid broader, deeper, and more substantial the foundations of a magnificent agriculture. These happy results have augmented the similar ones of 1903, so that a period of some industrial depression during the last two years has been saved by the farmers from the severer conditions that must otherwise have befallen in consequence of the absorption of a large portion of the readily convertible capital of the nonagricultural classes into great and prevalent speculations. Thus it has happened the farms of the nation have been that sustaining power upon which a basic dependence must be placed in all stresses by a people endeavoring to maintain economic self-sufficiency.

### WEALTH PRODUCED BY FARMERS.

As great as the financial successes of agriculture were in 1903, hitherto without equal, those of 1904 advanced somewhat beyond them. While some products have fallen behind in value others have more than filled the deficit, and the general result is that the farmers have produced in value much more wealth than they ever did before in one year.

One conspicuous item that has contributed to this is the corn crop. With a quantity closely approaching 2½ billions of bushels, near the record crop of 1902, the high price of this year gives this crop a farm value much greater than it ever had before, far exceeding a billion dollars. With this crop the farmers could pay the National debt and the interest thereon for one year, and still have enough left to pay the expenses of the National Government for a large fraction of a year. The cotton crop, including seed, became the second one in value in 1903, and remains so in 1904. It is now too early to state even with approximate accuracy what the farm value of this crop is, but indications are that the farm value of lint and seed must reach $600,000,000. In this case,

as in the case of all other statements herein made concerning crop values for 1904, it must be borne in mind that the amounts have not been finally determined by the Department, that the figures may be considerably changed when the annual estimate is made in the usual way, and that the values are at the farm, and are not commercial values at the exchange or anywhere else.

Hay and wheat are contending for the third place in point of value, although for many years one or the other has held second place or been next to corn. It is expected that these crops, hay and wheat, will together be worth on the farm this year nearly as much as the corn crop, or appreciably more than one billion dollars. Although the wheat crop has a considerably lower production than in any year since 1900, the farm value per bushel is higher than at any time since 1881, so that this is undoubtedly, by a considerable margin, the most valuable crop of wheat ever raised in this country.

It now seems probable that potatoes and barley reached their highest production in 1904; that the oat crop was never so large by 60,000,000 bushels, except in 1902; and that more rice was produced than in any previous year by toward 300,000,000 pounds, so that the present crop of rice has a commercial estimate of 900,000,000 pounds.

The principal crops that are valued annually by the Department or by commercial houses have an aggregate farm value this year which at the date of this writing apparently amounts to $3,583,339,609. The same crops in 1903, as finally estimated, had a farm value of $3,156,099,392 and had a census value for 1899 of $2,526,345,478. In these principal crops, therefore, the farmers find an increase in value for 1904 of 14 per cent over 1903 and of 42 per cent over the census year five years ago.

On account of the difficulty of estimating the present number and value of farm live stock, it must be sufficient to compare the farm equipment in this respect at the beginning of this calendar year as determined by this Department with similar statements made for 1903. Farm horses have increased slightly in number and more in value, and in the aggregate they never were so valuable as in 1904, with a total of $1,136,940,298. The value of farm mules also reached its highest point in 1904, $217,532,832. Cattle have declined a little in number and more in value, and the same is true with regard to sheep and hogs; but the steady advance of poultry in number and in the quantity and value of products leads to some astonishing values for 1904 when the census ratios of increase from 1890 to 1900 are extended to the present year. The farmers' hens are now producing 1⅞ billions of dozens of eggs yearly, and these hens during their busy season lay enough eggs in two weeks, at the high prices of eggs that have prevailed during the year, to pay the year's interest on the National debt.

## UNTHINKABLE AGGREGATES.

After a laborious and careful estimate of the value of the products of the farm during 1904, made within the census scope, it is safe to place this amount at $4,900,000,000, after excluding the value of farm crops fed to live stock in order to avoid duplication of values. A similar estimate made for 1903 gives $4,480,000,000, and the census total for 1899 is $3,742,000,000. It is by no means to be admitted that

these figures represent fully the value of the wealth produced on farms. Within the limits of ascertainable values, the farms of 1904 produced an aggregate wealth with a farm valuation that was 9.65 per cent above the product of 1903, and 31.28 per cent above the figures for the census year 1899.

An occupation that has produced such an unthinkable value as one aggregating nearly $5,000,000,000 within a year may be better measured by some comparisons. All of the gold mines of the entire world have not produced since Columbus discovered America a greater value of gold than the farmers of this country have produced in wealth in two years; this year's product is over six times the amount of the capital stock of all national banks; it comes within three-fourths of a billion dollars of equaling the value of the manufactures of 1900, less the cost of materials used; it is twice the sum of our exports and imports for a year; it is two and a half times the gross earnings from the operations of the railways; it is three and a half times the value of all minerals produced in this country, including coal, iron ore, gold, silver, and quarried stone.

## FOREIGN TRADE.

In the exportation of their surplus during the year ending June 30, 1904, the farmers of the country kept well up to the high level of recent years. The average annual value of the exports of farm products during the five years 1899–1903 was $864,930,137, and the value for 1904 was but little below, or $859,170,582. The year 1904 was exceeded by only two years, 1903 and 1901, in the value of exported farm products.

On the other hand, the imports of farm products for the fiscal year 1904 were higher in value than ever before, this value being $462,384,570, leaving an apparent balance of trade in farm products in favor of this country of $396,786,012, or the lowest balance in these products since 1897. The balance declined $25,495,220 in 1904. This is accounted for on the side of imports mostly by increases in the imports of coffee, wool, tea, cocoa, and chocolate; and on the side of exports it is accounted for principally by a decrease of over $72,000,000 in the value of exported grain and grain products which was not balanced by an increase of about $55,000,000 in the value of exported cotton.

During the last fifteen years the apparent balance of trade in favor of this country, all articles considered, was $4,384,574,143. This was owing entirely to the balance of trade in farm products, which during the same time amounted to $5,202,551,016, and was large enough to leave the above-mentioned balance of trade after sustaining adverse balances in products other than those of the farm, amounting to $817,976,963.

## INCREASE OF FARM CAPITAL.

The subject of the achievements and financial condition of the farming population may be pursued farther. While the farmers have been increasing their annual product of wealth since 1899 from great proportions to still greater ones, the value of their farm property has gone on increasing. Ratios of increase from the last three censuses indicate that since 1900 the farm land with improvements, including buildings, have increased in value 1⅞ billions of dollars; the imple-

ments and machinery, over $100,000,000; the principal classes of live stock (corrected by the Department's information), $240,000,000. Hence the apparent total of the increase in the value of farms and farm property within four years amounts to about $2,000,000,000, a total that seems to be under the fact, since it does not recognize the marked increase in cotton, corn, wheat, and other lands with high crop values during the last two years. The cotton crop brought to planters not merely an increased price per pound, but it at once made cotton lands more valuable to the extent of several dollars per acre, according to numerous reports received by the Department.

### EVIDENCE OF THE BANKS.

The improved financial condition of the farmer is indicated expressively by deposits in banks in several States in which there is so little manufacturing and mining that the conditions are chiefly created by agriculture. The three agricultural States—Iowa, Kansas, and Mississippi—may be selected for a comparison with the United States as a whole. Individual deposits in the National banks of Iowa increased from June 30, 1896, to October 31, 1904, 137 per cent; Kansas, 212 per cent; Mississippi, 286 per cent; the United States, 92 per cent, or much below the increases of the States named. In the State and private banks deposits during this time increased 128 per cent in Iowa, 227 per cent in Kansas, 306 per cent in Mississippi, and 185 per cent in the United States. In the savings banks of Iowa the increase in deposits was 215 per cent, as compared with 53 per cent for the United States. All kinds of banks being combined, the deposits increased 164 per cent in Iowa, 219 per cent in Kansas, 301 per cent in Mississippi, and 91 per cent in the United States.

A similar comparison favorable to the agricultural States may be made with regard to the number of depositors. In the savings banks of Iowa the number of depositors increased 209 per cent from 1896 to 1904, and in the United States 36 per cent. For National banks, comparison may be made between highly industrial and agricultural States as follows: The number of depositors increased from 1889 to 1903 by 145 per cent in Massachusetts, 117 per cent in New York, 258 per cent in Kansas, and 263 per cent in Mississippi. The increase in Iowa was 184 per cent, the low figure being accounted for by the large development of savings banking.

The Comptroller of the Currency has ascertained the average amount of the daily deposits in National banks, and from his statement it appears that the average daily deposits in October in the National banks of Kansas increased 625 per cent from 1889 to 1903, in Iowa 105 per cent, in Mississippi 89 per cent, in Massachusetts 106 per cent, and in New York 207 per cent.

The farmers' rate of financial progress, as evidenced by the foregoing statements, need fear no comparison with that of any other class of producers. The farmer may not become a millionaire, but he is surer than the millionaire to retain his wealth and to have independence in living.

### GENERAL DIFFUSION OF WELL-BEING.

The diffusion of well-being among farmers throughout all parts of the country is one of the most conspicuous features of the recent agricultural development. This attracted attention a year ago and is now

even more noticeable; because the great South is more especially enjoying this growth of well-being, owing to the enhanced value of the cotton crop in addition to the general progress in agriculture. The Eastern farmer, who was long on the verge of bankruptcy in competition with the virgin soil and rapid expansion of the northern half of the Mississippi River Valley, has survived that competition and now enjoys more normal conditions, owing to the creation and maintenance of many large near-by markets by many varied industries. The Pacific Coast has long been prosperous with its world-famed specialties; the mountain States are glad with the fruits and promises of irrigation; in the older prairie States the farmer has seen his land go from $1.25 an acre, or from a homestead gift, to $100 and $150; and the "Great American Desert," as it was called when it was nothing but a buffalo range, is now peopled by a progressive race of farmers, whose banks are filled to overflowing with the proceeds of their products.

## WEATHER BUREAU.

### OBSERVATORY BUILDINGS.

Carrying out the policy of the Department, the Weather Bureau has continued to cooperate with the leading universities throughout the country, and at the present time the relations existing are more intimate and the work done more important than at any time in the history of the service. Several universities and colleges have donated ground for the erection of buildings. Appreciation of the value of the work being done by the Weather Bureau has also been demonstrated by several universities in placing at the disposal of the Bureau, without cost, office quarters in their buildings for recently established stations. The erection of buildings by the Weather Bureau saves the amount previously paid for rent of office quarters.

### FORECASTS.

Weather forecasts for thirty-six and forty-eight hours in advance have been made daily throughout the year for each State and Territory, and special warnings of gales on the seacoasts, Gulf, and Great Lakes, and of cold waves, frost, heavy snows, floods, etc., have been issued when the advices would benefit commercial, agricultural, and business interests. The North Atlantic and West Indian storm-warning service was continued, and forecasts for the first three days out of steamers bound for European ports were issued daily at 8 a. m. and 8 p. m. In a number of instances European shipping interests were notified of the character and probable course of severe storms that were passing eastward from the American coast. Daily warnings and advices issued in connection with the injurious weather conditions of the year resulted in saving much property.

### RIVER AND FLOOD SERVICE.

The floods of the year did not approach in character and importance the overflows of the spring of the year immediately preceding, when over 100 human lives were lost, besides property valued at

over $40,000,000. There were, nevertheless, severe floods at various times, and in the management of the work occasioned by them the river and flood service continued to demonstrate its usefulness and growing efficiency as a valuable branch of the Weather Bureau. That there has been constant progress in the accuracy of its work is evidenced by the more specific and detailed character of the forecasts and warnings in localities where such exact work had heretofore been considered practically impossible. The service performed during the prevalence of the great winter ice gorges in the Susquehanna, Allegheny, and Ohio rivers, with their attendant floods, was especially noteworthy. These gorges were the greatest in the history of the localities, and that their great dangers were minimized is due in no small degree to the timely advices and warnings of the Weather Bureau.

There were minor floods during nearly every month of the year, but each was amply covered by timely warnings. These floods were not in any sense alarming or dangerous, but they nevertheless attained sufficient importance to endanger a large amount of property.

### CLIMATE AND CROP SERVICE.

The National weather and crop monthly and weekly bulletins and the annual summaries and monthly and weekly bulletins issued from the 143 section centers, also snow and ice bulletins, daily bulletins issued in connection with the corn, wheat, cotton, sugar, rice, and fruit services during the growing season, and the special snow bulletins issued during the winter by the sections in the Rocky Mountain and Plateau regions have appeared regularly during the year and have been of great value in affording timely information.

### DISTRIBUTION OF FORECASTS AND SPECIAL WARNINGS.

The extensive distribution of daily forecasts by means of forecast cards has continued, and the railway, telegraph, and train services have supplied in the aggregate over 5,000 railroad stations with bulletins generally posted in the waiting rooms for the benefit of employees and the traveling public. The number of addresses on the rural free-delivery list has been greatly decreased as compared with that of the previous year, owing principally to the discontinuance of the afternoon forecast at some of the centers and the transfer of a large portion of this work to the free telephone service. The rural telephone lines are now the best and most economical means of distributing weather information. The forecasts are quickly disseminated, covering a large territory with little or no expense to the Government. By arrangements made with two of the great trunk telephone lines of Ohio the daily morning forecasts are now available for the use of more than 100,000 subscribers in that State, and the records indicate that nearly one-half of that number have taken advantage of the opportunity to get the forecasts in their homes within a few minutes after their preparation at the district center.

### MOUNT WEATHER METEOROLOGICAL RESEARCH OBSERVATORY.

During the past year the main building of the Mount Weather Observatory has been completed, while the power plant, the building

from which balloon ascensions and kite flights are to be made, and the magnetic building are being constructed. The physical laboratory for electrical and radioactive effects is being planned, the erection of which will take place in another year. Finally, a comprehensive physical observatory for photographing the sun directly and through the spectrum, for measuring radiation energy by actinometry and bolometry, with their allied equipment, will be required. This complex institution must grow up slowly as plans can be matured along the best modern lines. When the equipment is ready we shall make and send out apparatus for the exploring of the atmosphere to altitudes of from 3 to 10 miles. It is probable that many balloons will be simultaneously liberated from different stations so as to get records of storms and cold waves from their four quadrants. With observations from the magnetic, the electric, and the solar physics observatories, opportunity for study will be given to those who believe that the cyclonic and anticyclonic whirls that constitute storms and cold waves are mainly the result of changes in the amount or intensity of some form of solar radiation. It is the purpose to make the research at Mount Weather catholic in its broadness.

### WIRELESS TELEGRAPHY.

The Department of Agriculture, through the Weather Bureau, was one of the first of the Executive Departments to take up, systematically, experimentation in problems concerned with the development of wireless telegraphy. By this action research into the physical problems concerned in transmitting messages through the medium of ether waves was greatly stimulated in this country. Probably one of the best, if not the best, instruments anywhere made for the receiving of wireless messages had its inception in the experimental work of the Weather Bureau. Recently a board was appointed by you to consider the whole problem of wireless telegraphy and the relation of the Government thereto. Its recommendations, which you approved, will result in the discontinuance of experiments along this line by the Weather Bureau, their transfer to the Navy Department, and the transfer to the Weather Bureau of all the meteorological work now being done by the Navy Department.

### LONG-RANGE FORECASTS.

It is hoped the time will come when it will be possible to forecast the weather for coming seasons, to specify in what respect the coming month or season will conform to or depart from the weather that is common to the month or season; but that time has not yet arrived, and the officials of the Weather Bureau have been informed that they will best serve the public interests when they teach the communities they serve the true limitations of weather forecasting.

### EDUCATION IN METEOROLOGY.

The Department is interested in the general introduction of meteorology into the courses of study provided by the universities and higher technical institutions of the country. The mode of teaching and the results obtained were made an important part of the work of the

Convention of Weather Bureau Officials which was held at Peoria, Ill., in September, 1904. At an increasing number of educational institutions Weather Bureau officials, in addition to their regular duties and mainly outside of office hours, deliver courses of lectures on meteorology.

### TELEGRAPH SERVICE.

To meet as far as possible the pressing demands for a wider distribution of the daily telegraphic reports of observations, arrangements were perfected during the year for a very generous increase in the number of such reports telegraphed over circuits and as special messages, and while for economical reasons it is impossible to satisfy all demands in this respect, it is believed that the present distribution of reports will result in a much more comprehensive display of weather conditions on the maps and bulletins and will give general satisfaction both to the public and to our officials charged with making district and local forecasts. Submarine cables have been laid from Block Island, Rhode Island, to the mainland; from South Manitou to North Manitou Island, Michigan; from Flavel, Oreg., across the mouth of the Columbia River to Fort Canby, Wash.; and preparations are being made for laying one from North Nags Head to Manteo, Roanoke Island, North Carolina.

The reorganization at the beginning of the year of the vessel and wreck reporting service of the Weather Bureau, with additional stations at Sand Key, Florida, and Southeast Farallone, California, has largely added to the effectiveness of this popular feature of the Bureau, and is much appreciated by maritime interests generally. Vessel and wreck reports are now furnished free of charge, except for telegraph tolls over commercial lines, to all corporations and individuals who may apply for them. Besides reporting passing vessels, an important service is rendered by these stations in connection with maritime disasters.

### INSTRUMENTAL EQUIPMENT.

The Bureau has now 158 stations completely equipped with instruments by means of which an automatic record is made of the direction and velocity of the wind, the duration of sunshine, the amount and time of beginning and ending of rainfall, and the temperature and pressure of the air. With one or two exceptions the stations that are not at present so equipped are of slight importance, or in general have all the instruments necessary for the satisfactory performance of their work. One hundred and fifty-nine steel towers, with the improved auxiliary equipment for the display of storm warnings, are now installed at as many stations distributed over the shores of the Great Lakes and the Atlantic and Pacific seacoasts. At 77 of these stations high-power electric lanterns are used, and at the others improved oil lights.

## BUREAU OF ANIMAL INDUSTRY.

Our animal industry is shown only in small part by the figures giving the exports, yet these exports are so large as to be worthy of notice. The animals exported in the fiscal year 1904 were valued at about $48,000,000, which was an increase over the previous year of

$13,000,000; the exports of meat and meat products, including oleo oil, oleomargarin, and lard compounds, amounted to more than $174,000,000, a decrease of $4,000,000 from the year before. We also sent abroad nearly $6,000,000 worth of dairy products, and of other animal products, such as hides and skins, glue, grease, and grease scrap, over $5,000,000 worth. The exact total of the above items of export, as given in preliminary returns, was $223,023,060, which was an increase over the previous year of more than $12,000,000. The Department is fostering this foreign trade, as well as safeguarding the live-stock industry within our own country.

### INSPECTION OF ANIMALS FOR EXPORT.

The inspections of live stock for export included Canadian animals that pass through territory of the United States; these numbered about 26,000 cattle and 60,000 sheep. The total inspections for export, including these Canadian animals, were 790,496 for cattle, 534,850 for sheep, and 3,293 for horses. As compared with similar figures for the fiscal year 1903, this statement shows an increase of 43.7 per cent in the number of American cattle exported and an increase of 116.5 per cent in the number of American sheep exported. The number of horses exported, however, was reduced by one-third.

The percentage of loss in transit for the 360,990 head of American cattle landed at the ports of London, Liverpool, and Glasgow was but 0.17; the percentage of loss for the 212,299 American sheep landed at the same ports was 0.94.

The number of clearances of vessels engaged in carrying live stock was 774, and the certificates of inspection issued for American cattle exported to Europe numbered 1,419.

### INSPECTION OF IMPORT ANIMALS.

The work of the inspection of import animals calls for the utmost vigilance in order to prevent the introduction of diseases which might prove disastrous to the live stock of this country. Most of the animals that came through the seacoast ports of entry were imported for breeding purposes, but a considerable number of cattle were admitted from Mexico for feeding. The importations of pure-bred animals subject to quarantine were very light during the year, the number at New York, the chief port of entry, having been 266 cattle, 128 sheep, and 123 hogs. The number of farm animals that came through seacoast ports and not subject to quarantine was 2,492; of this total 2,425 were horses. We brought from Great Britain 1,523 horses, from Germany 204, from Belgium 651, and 47 from other countries.

The importations of animals from Mexico were 12,088 cattle, 701 sheep, 314 horses, and various other animals to the number of 203.

An unusually large number of ruminants for menageries, all of which were subject to inspection and quarantine, were imported during the year.

### INSPECTION OF MEAT.

The inspection of animals and animal products was maintained at 51 establishments and cities. The total number of ante-mortem inspections was about 65,000,000, whereas in 1903 the number was about

59,000,000; this shows an increase of 6,000,000 animals. The post-mortem inspections amounted to nearly 40,000,000, which was an increase, except as to sheep, over the year 1903. The increase in 1904 in the number of hogs inspected post-mortem was over 2,000,000.

The meat-inspection tag or label was affixed to 22,943,067 quarters and 120,404 pieces of beef, 8,230,528 carcasses of sheep, 765,301 carcasses of calves, 1,122,193 carcasses of hogs, and 726,779 sacks of pork. Besides, the meat-inspection stamp was affixed to 23,000,000 packages of meat and meat products that had received the regular post-mortem inspection.

Compared with the figures of 1903, the statement for 1904 shows an increase in beef exports of 47,138,044 pounds, a decrease in mutton exports of 2,016,924 pounds, and an increase of pork exports of 21,319,830 pounds—a net increase of 66,440,950 pounds for all.

In the matter of the microscopic inspection of pork there was a great decrease, from 19,000,000 pounds in 1893 to 9,000,000 in 1904. This inspection is restricted to the pork that is destined for those countries which require such safeguard. The number of carcasses thus inspected in 1904 was 315,045. The number of carcasses found to be trichinous was 2,643.

The cost of the ordinary inspection was $781,590.95, and the microscopic inspection cost $53,934.01. Each hog carcass cost 17.1 cents for its inspection and each pound of pork exported 0.6 cent.

## CATTLE SCAB, OR MANGE.

The existence of scab, or mange, in cattle has for several years past often been brought to the attention of the Department. As early as the spring of 1901 inspectors in the field recognized that scab of cattle was a contagious disease, and asked for instructions regarding it. The disease continued to spread, and during that year numerous inquiries were received as to how the disease could be cured and controlled. It became generally known that the dipping of cattle was the best method of treatment, and the Department received many calls for information as to the construction of vats and the best dips to use. In January, 1902, a bulletin describing scab of cattle and its treatment was issued. There was a large individual demand for this publication and it was supplied to many State authorities for general distribution.

In spite of efforts to disseminate all the information possible on the subject, the disease spread to an alarming extent, especially on the Western ranges, where the cattle roamed over large areas, and where a few infected animals introduced would communicate the disease to others until the whole band was affected. So extensive was the distribution of the scab that in June, 1903, the Department issued regulations for controlling it, stating that the disease existed among cattle in that part of the United States lying west of the Mississippi River, including the State of Minnesota. These regulations did not apply to the Eastern part of the United States. At that time all of the available funds were used for the employment of inspectors in the Western country in the eradication of scabies among sheep, and there were but a few men who could be used for enforcing the regulations for preventing the spread of scabies among cattle. Many of the Western

States, notably Colorado, began during this year to take measures for suppressing the malady within their limits. These States, however, were unable to prevent the disease from being introduced from other States, consequently very urgent appeals were made from State authorities asking that supervision by this Department be extended to cattle scab.

It was apparent that, unless the Federal authorities undertook measures for its control, the States would suffer disaster, not only from the loss of stock affected, but from the embargo which would be placed upon cattle passing from an infected State to one where the disease did not exist. The disease became so prevalent that it was carried from the ranges to the feed lots in States of the Middle West, and there was danger of injury to the trade in live cattle for export to Great Britain. When the scab became so common on the ranges, it was found that unless the cattle were dipped before shipment the cars in which they were loaded became infected; also the stock pens, where the cattle were unloaded for food and rest en route, as well as the stock yards at the leading markets. It became imperative, therefore, that a campaign should be entered upon, and accordingly in March, 1904, regulations were issued applying to all of the United States and prohibiting shipment of cattle affected with this disease from one State to another.

Provision was made in these regulations for allowing shipment after cattle were dipped, and, though affected with the disease, they could be shipped for immediate slaughter after one dipping; but if cattle were intended for feeding or stocking purposes, they must be held for the second dipping, ten or twelve days after the first one. To secure the enforcement of these regulations, it was necessary to station a large number of inspectors in the Western States, particularly the range States where shipments of cattle originated and where the disease was most prevalent. So far as possible the force of inspectors already in this region was used; but this was entirely inadequate to the demands and required an extensive increase, so that at the present time more than two hundred men are in the field engaged in the inspection of sheep and cattle for scabies.

There was an urgent call for inspectors, mostly from persons who had cattle to ship and those who owned affected cattle which required dipping. This dipping in several States was done in cooperation with the State authorities and under the supervision of Federal employees. Shipments of cattle from ranges known to be infected could not be made to market centers without a certificate showing freedom from scabies, or to the effect that the cattle had been dipped and could be transported without spreading the contagion.

During the first nine months of this year, in the 34 States and Territories where this inspection was maintained, 3,843,075 cattle were inspected for scab; 168,203 were found affected with the disease, and 300,275 were found to have been exposed to it. The total number of cattle dipped during this period, under official supervision, was 420,762; 116,362 affected cattle were given one dipping, and 76,974 affected cattle were dipped a second time, after an interval of ten or twelve days. This work necessarily increases the expenses of the Bureau, which, for the month of January, 1904, amounted to $404.65 for this inspection exclusively, and in September, 1904, to $11,770.70.

### FOOT ROT AND GID OF SHEEP, AND RABIES.

Besides the several lines of work which have been carried on through a series of years and which have been reported upon from time to time, special work has been done with reference to foot rot of sheep and the disease of sheep commonly known as "gid." In a recent shipment of sheep which arrived at the Buffalo stock yards 75 per cent were found to be affected with foot rot. This disease is not at all uncommon in the sheep-raising parts of the country, and its eradication is not a very difficult undertaking. A bulletin is now in press which deals with all of the phases of foot rot, and should enable the sheep raiser to clean up his flock without much difficulty or great expense.

Although the conditions prevailing in this country are considered unfavorable to the parasite causing gid, the disease, nevertheless, has gained a foothold in the Rocky Mountain States, and it is therefore well to understand the life history of the parasite causing the disease and the methods of dealing with it. It is reported that a few years ago the loss of sheep from gid in France was as great as 1,000,000 annually. This subject has received a thorough investigation, the results of which will soon be published.

Investigations regarding the presence of rabies, or hydrophobia, in the vicinity of Washington, D. C., were continued during the year. Of the 38 suspected cases examined positive results were obtained from 22, of which number 13 were from the District of Columbia.

### TUBERCULOSIS.

The work on the subject of tuberculosis has been conducted throughout the year along lines which have been planned for several years. Some experiments which have been recently reported upon by this Bureau go to show conclusively, it is believed, that it is an error to conclude that cattle can not be infected with human tuberculosis. These experiments not only justify but show the desirability of a rigid enforcement of public regulations looking to the control and the eradication of tuberculosis in cattle.

The demand for tuberculin greatly increased during the year. The amount distributed in 1904 was 74,000 doses, while in 1903 the number of doses was 47,000.

### DISTRIBUTION OF BLACKLEG VACCINE AND MALLEIN.

The blackleg vaccine for cattle which is manufactured and distributed by the Bureau of Animal Industry continues to give satisfactory results. During the year the number of doses that were sent out fell off somewhat from the report of the previous year, but the number of persons supplied was slightly increased. It is interesting to note that, in 1904, 1,000,000 doses of the vaccine were used and reported upon by over 10,000 persons with highly satisfactory results. After a careful analysis of the figures which were compiled from the reports from the users of blackleg vaccine, and eliminating the deaths which could in no manner be properly charged against the action of the vaccine, the number of cases that died after vaccination is reduced to the very low figure of 0.44 per cent.

The manufacture and distribution of mallein in 1904 for glanders in horses was about the same as in the previous year, and the number of doses sent out was 7,000.

### INSPECTION OF DAIRY PRODUCTS.

Under the act of Congress approved May 9, 1902, the Bureau of Animal Industry is charged with the inspection of certain dairy products which are designed for interstate commerce, especially the article of renovated butter. This work is now fully organized and is governed by joint agreement of the Treasury Department and the Department of Agriculture. The reports for 1904 show that there were 73 factories licensed and bonded, which was a reduction of 9 from the previous year. These factories were located in 14 States and the District of Columbia. The quantity of renovated butter made at bonded factories during the fiscal year of 1904 was about 54,000,000 pounds. The average quality of renovated butter is improving. The difference in general character, since the inspection was inaugurated, is very marked. This is due, in part, to improved machinery and processes, and largely to the better average quality and condition of the "packing stock" or raw material used.

Such stock is now closely collected in the producing districts, so that accumulations of country butter at remote points and involving deterioration are not frequent. More care is taken in sorting, packing, and storing the stock. Occasionally a lot of packing stock is found in such a condition of filth or putrefaction as to necessitate condemnation. In still rarer cases the manufactured product is found to be so bad, because of bad materials, ignorance, or negligence in renovating, or as the effect of age, as to make it unfit for food. In a few such instances the sanitary inspection required by law and made by this Department has caused the objectionable materials and products to be removed from the food market and sold as grease. But, as stated, such instances are not frequent. Although there is still opportunity for great improvement in materials, in the manner of handling and transporting the same, in factory management, and in the finished product, it is true that the manufacturers are endeavoring, as a rule, to improve conditions at all points and are ambitious to win a reputation for producing an article of high quality.

## BUREAU OF PLANT INDUSTRY.

In no field of industrial work have there been greater advances during the past decade than in the improvement of plants and the methods of growing them. The Bureau of Plant Industry has done much to bring about these advances. Diseases have been studied and remedies found, new varieties of plants have been created and new industries established, and the world has been searched for better things, all for the purpose of helping the farmer and making his work less burdensome and more profitable.

### GROWTH OF THE WORK.

Since the Bureau of Plant Industry was organized, three years ago, the demand for more work has been so great as to require an increase of nearly 50 per cent in men and funds to conduct it. There are now in the Bureau about 500 workers, 60 per cent of whom are engaged in scientific investigation and its application to the farm, the orchard, and the garden. The Bureau is endeavoring to train young men as rapidly

as possible for this work. The agricultural colleges furnish a part of these men, but the demand for those with proper qualifications is still greater than the supply.

### ENCOURAGING INTEREST IN FARM LIFE.

The Department is not an educational institution in the strict sense of the word, but it can do and is doing much to bring home to the people in all walks of life the importance and value of the farm and its productions. The Bureau of Plant Industry is making a special effort to encourage the study of plants in the public schools. The future welfare of this country depends upon its agricultural development, and it is important and vital that a knowledge of the opportunities in this field should early be brought to the attention of the child. Unfortunately, our system of elementary education is such as to leave no impression on the child's mind of the importance, value, and usefulness of farm life. The child is, in many ways, brought early into contact with facts which point to him the value of commercial life. He is, therefore, early inoculated with the belief that to reach the highest possibilities he must, if he is on the farm, migrate to the city. It is to be regretted that farm life in the past has not always been conducive to the encouragement of young men to remain on the farm.

Very little effort has been made to overcome the general belief that there is always a great amount of drudgery connected with the farm, and that the opportunities in this sort of occupation are narrow and limited. When we see the rapid advances that are being made in agriculture along all lines and note the need for bright young men in this field, the opportunities offered by the cultivation of the soil seem as great as in any other field. In order to bring these matters clearly home to the children, efforts are being made by the Department to encourage the growing of plants in connection with the public school work. The general distribution of seed is being handled in such a way that the encouragement of plant growing will be a feature of it. Wherever it has been practicable to influence school authorities, this has been done. Various members of the staff of the Bureau are constantly endeavoring by publication of papers, lecturing, etc., to point out the advantages of rural life.

### DEVELOPING NEW INDUSTRIES.

#### RICE PRODUCTION.

The Bureau of Plant Industry has continued its efforts to encourage rice production in the Southern States, especially in Louisiana and Texas. A special farm for the growing of rice has been placed at the disposal of the Department, and upon this farm various questions relating to the industry are being worked out. New varieties of rice are being tested, questions pertaining to the best methods of improving the seed are being settled, and other important problems are under investigation. There has been an enormous increase in the production of rice in the States of Louisiana and Texas during the past three years. As the industry has developed, the necessity has become more and more evident for paying special attention to the improvement of cultural methods.

In the early days of the industry the crop was so profitable that little attempt was made to obtain information on important matters, such as the necessity for rotation, the best methods of handling the water, means of controlling diseases and weed pests, and other important subjects. As competition has become greater and the production larger, farmers are realizing the necessity for paying strict attention to all details connected with the work. Preliminary estimates show that during the year 1904 the area devoted to rice in Louisiana and Texas was 600,000 acres, and the crop will approximate 650,000,000 pounds of rough rice.

### DURUM WHEATS.

The success attending the introduction and growing of the durum or macaroni wheats continues unabated. The past season has been a particularly trying one for all wheats in the Northwest. Rust has caused great damage in many localities, but the durum wheats have been in most cases resistant. Probably no less than 14 million bushels of these wheats will be grown the present season, and the evidence at hand indicates that great quantities of the wheats are being saved for seed for next year's planting. Owing to the almost total loss of other wheats east of the area where the durum wheats succeed best, efforts will probably be made next year to plant the durum wheats farther east than they should be planted. It must be remembered that these wheats are specially adapted to semiarid regions, and moving them into humid regions may result in disappointment.

It is gratifying to announce that the durum wheats are now being handled without difficulty by many of the millers, and regular grades corresponding with the grades of other wheats have been established in the markets. From the outlook at present there will be not less than 40 or 50 million bushels of these wheats produced next year. The fact that these wheats are valuable for bread and that they can be grown successfully where most other crops fail is an exceedingly important thing for the agricultural development of the great semiarid West.

### THE MATTING INDUSTRY.

The United States imports large quantities of mattings from the Orient. These mattings, for the most part, are made of a species of rush which might easily be grown in this country; in fact, there are already here several native forms which undoubtedly would prove valuable for the manufacture of fine mattings. Special American machinery has been devised and is now in use in the manufacture of a very high grade of mattings. So far, the raw material used by these machines has been imported. During the year the Bureau of Plant Industry has introduced and disseminated considerable quantities of the rush, with the object of securing a sufficient amount to supply American manufacturers with the product. The results accomplished have already proved encouraging, and the work will be continued.

### SUGAR-BEET GROWING.

The development of the sugar-beet industry continues satisfactory. The Bureau of Plant Industry is making an effort to improve the conditions affecting this crop in the matter of providing better seed,

encouraging the use of fertilizers where fertilizers are likely to do good, studying the diseases with a view to discovering remedies for them, securing improvement in the matter of seed by the production of beets which will give seed of a single ball or germ, etc. A little more than two years ago the Department again took up the work of establishing sugar-beet seed culture in the United States, and since that time work has been going on in four representative sections of this country. Strains of pedigreed seed are being established in New York, Michigan, Utah, and Washington State, while in Utah and Washington the industry is already assuming commercial importance.

In California also seed is being produced for local use. In Washington State 80,000 pounds of seed were produced in 1904, in Utah about 32,000 pounds, and in California about 50,000 pounds—a total of 162,000 pounds. As rapidly as the Department can bring home to all the sugar-beet factories the conviction that American-grown seed is as good and often better than the imported, these quantities will be increased, and it is a question of but a few years when the entire 5,000,000 pounds used in the United States will be produced at home.

As to the quality, American-grown seed has produced beets testing as high as 24 per cent of sugar, while the average percentage in all beets tested from American-grown seed during 1903 was 15.8 per cent. The average percentage of sugar in all beets grown in the United States, as shown by the factory returns of their total extractions, is a little over 11 per cent. It will be remembered, too, that the American seed has the benefit of only two years of careful selection. The work of establishing a pedigreed strain is slow, and years are required for the completion of such an undertaking; but the work is so far along that its success may be considered assured.

Two years ago the Department imported all the sugar-beet seed that was distributed for experimental purposes, while during the 1904 season 14,000 pounds of American-grown seed were distributed by the Department to selected farmers for testing in comparison with imported seed furnished to them by the factories. The reports on the stand secured, which is generally indicative of the yield, show that the American seed gave almost without exception a greater and a stronger growth than the imported seed. In a number of instances those portions of fields which were sown with factory seed gave such a poor stand that they had either to be resown or abandoned, while the portions sown with American-grown seed gave good stands and in no case required replanting. The factories during 1904 bought 34,500 pounds of American-grown seed, and a number of these factories are now negotiating with the American growers for contracts to supply the seed they need.

In the fertilizer work efforts have been made to determine the effect of different fertilizers on tonnage and sugar content, and also their influence on various diseases.

Investigations along this line were undertaken in six sugar-beet States, seven brands of complete fertilizers being used, and in addition some separate experiments with the various ingredients used by themselves were made. The preliminary reports which have been received indicate that in many cases the effect of the fertilizers could be seen from the time of the germination of the beets. In a few cases the lines separating the fertilized from the unfertilized plots could be seen even at the beginning of the harvest. A recent report from one

of the experimenters states that in his work with nitrate of soda the beets from the untreated plots were worth $5.20 per ton and yielded $54.35 worth of beets per acre. On the adjacent plot, where 300 pounds of nitrate of soda were applied at the time of planting, the beets were worth $5.30 per ton and yielded $74.57, a difference of $20.23 per acre in favor of the fertilization. The untreated beets tested 14.1 per cent sugar, while those fertilized tested 14.4 per cent.

The serious epidemics which have affected the sugar beet, like the leaf-spot disease of the East and the curly top of the West, have been investigated. Experiments on a large scale in different sections of the Eastern beet area have shown that the leaf-spot may be readily controlled by the application of Bordeaux mixture. This remedy has now come into general use.

In my last report attention was called to the efforts being made in the matter of developing sugar-beet seeds with single germs. The single-germ seed would do much to diminish the labor of thinning. The Bureau work in this field has been very satisfactory. Although the work has been running for only two seasons, decided progress has been made, and the single-germ seeds that have been selected have been found much more vigorous than the multiple-germ balls. The selected strains grown this year show a decided tendency to the production of a larger number of single-germ balls than the parent beet from which the selection was started, the average gain being about 20 per cent. In one case, over 3,000 single-seed balls were found on one beet. The work this year has been conducted in Utah and other sections where the sugar beet is at its best, and indicates that ultimately we shall in all probability be successful in the production of a beet having the desirable quality of producing only balls with single germs, that will substantially save hand thinning and avoid much expense in growing.

### NEW CITROUS FRUITS.

The efforts that have been made by the Bureau of Plant Industry for a number of years in the matter of producing, by breeding, new citrous fruits, so as to build up varied industries in the South, have met with very gratifying results. The hardy sour oranges which have been secured as a result of crossing the sweet orange with the hardy Japanese orange are now ready to distribute, and the work of distribution will be inaugurated in the coming winter. These new hardy oranges will unquestionably make possible the development of several important industries in the South. The oranges are valuable for marmalades, and from the fact that they may be grown in nearly all the Southern States, great possibilities for their usefulness are opened up. Even if they should not come into general use for manufacturing purposes or for general orchard planting, they will undoubtedly eventually become a feature in every dooryard throughout the South. Aside from their value for the manufacture of marmalades and preserves, they will be exceedingly useful for pies and other purposes.

There has been fruited this year for the first time a sweet orange of the hardy type. This is an accomplishment which the Department hoped for when it first inaugurated the work. The other new citrous fruits developed from the Bureau's investigations, such as the new tangelo, which is a cross between the tangerine and the pomelo, a new velvet-skin orange, and several other creations, will all prove exceed-

ingly valuable in sections where the climatic conditions will permit the growing of these more tender sorts.

### AMERICAN TEA.

The Department has continued its work in the production of American tea. The more advanced investigations have been conducted, as heretofore, at Summerville, S. C., in cooperation with Dr. Charles U. Shepard. Doctor Shepard's tea gardens are now yielding from 8,000 to 10,000 pounds of tea annually. Owing to climatic conditions the crop this year will be light. Doctor Shepard has been devoting special attention to the improvement of factory processes. Several new inventions have been made by him in the matter of tea rollers, apparatus for the manufacture of green tea, and apparatus for a process of attrition, giving to the tea the beautiful bluish cast, or finish, which heretofore has been secured in foreign countries by the application of various chemicals.

Doctor Shepard's process puts this finish on the teas by simple attrition or friction, and is a marked advance over the old processes. The work of establishing a plantation in Texas has been continued. Tea beds were started on two types of soil—a rich sandy loam and a black, waxy soil. The plants on the black, waxy land have failed utterly. Fortunately this discovery was made before any extensive plantings had been undertaken, and it will lead to the extension of the plantings on the sandy loam soil. There are now on hand at our Texas station, which is located at Pierce, about 100,000 plants, which will be put into the field this winter, planting about 40 acres. Sufficient additional seed will be put out to give another 50 acres next year.

### AMERICAN DATES.

Encouraging results have been secured in the establishment of this industry in the southwestern portion of the United States. The date orchard at Tempe, Ariz., is progressing in a highly satisfactory way. The work here has been carried on in cooperation with the Arizona experiment station and has been under the direct supervision of Prof. R. H. Forbes. In cooperation with the California experiment station, work on the establishment of date culture in southern California is also being conducted. Ten acres of land have been secured for an experimental orchard and dates have been and are being planted there. The industry has been further encouraged by the publication of important reports on the subject, pointing out available localities where the crop is likely to succeed. There is a considerable extent of territory in southern California where practically all of the dates of a certain class which are now imported could in all probability be grown. These regions have been mapped and a special effort has been made to encourage the production of the crop therein. Various importations of the date have been made during the year and others will follow from time to time as the industry advances.

### BULB GROWING.

The very specialized conditions of soil and climate necessary for the proper production of bulbs and the peculiar nature of the skilled labor required have made the establishment of the bulb industry difficult.

However, investigations have shown that nearly all of the so-called Dutch bulbs may be grown in the United States, and that one by one the difficulties due to competition of cheap skilled labor, excessive cost of transportation, and the natural hesitancy on the part of purchasers to use an untried article will be overcome. A method has also been discovered by the Department experts to produce the Bermuda lily bulb free from disease. Of the millions of lily bulbs annually imported, it is safe to say that 40 per cent are more or less affected by disease. The eventual elimination of this trouble will be due to the work of the Department.

### AMERICAN-GROWN DRUG PLANTS.

In Vermont, the previous success in growing opium poppies has been repeated with even more satisfactory results, both the white-seeded and blue-seeded sorts giving good crops. The attempt to cultivate this plant has been made with the object in view of testing the possibility of developing in this country a means of supplying our demand for poppy alkaloids for medicinal uses. The present source of these—morphine, codeine, etc.—is to be found in crude opium, of which approximately a million dollars' worth is imported annually. The cost of these products is in large part due to the labor involved, and the efforts of the Bureau have been directed toward devising some process whereby the alkaloidal principles can be isolated directly from the extracted juices of the plant. Up to the present time no one has succeeded in obtaining morphine from these extracts.

During the year an expert of the Bureau has, however, met with success, and we are now able to obtain morphine directly from the expressed juices of the plant. This method does away with much of the expense. Experiments are now being undertaken to ascertain the practicability of obtaining morphine directly from the plants as a commercial source. If the experiment indicates a favorable outcome the plants produced in American fields will replace oriental opium as a crude source for morphine.

### SWEDISH SELECT OAT.

The experiments of the Department with this hardy Swedish oat ceased some time ago, but highly interesting reports in regard to its usefulness are still coming in. It was introduced about five years ago by the Bureau of Plant Industry and distributed in a number of the Northwestern States. It has high qualities as a yielder and is especially valuable for resisting drought.

It has now become the most popular variety in the States of Wisconsin, North Dakota, Montana, portions of Idaho, South Dakota, and Minnesota. In one instance in Wisconsin, from the planting of 33 grains in the spring of 1899, there resulted a production of about 20,000 bushels in the year 1903, and a half million bushels in the present year, 1904. It is expected that the present year's crop will show that about 4 million bushels of this oat are being produced in Wisconsin. Although the highest legal weight of oats is 36 pounds to the bushel, this variety commonly weighs from 40 to 44 pounds in the Northern States, and occasionally reaches from 48 to 50 pounds to the bushel.

### SPECIAL WORK ON COTTON.

The Bureau of Plant Industry has made a special effort to aid the farmers of Texas, Louisiana, and other Southern States where the Mexican cotton boll weevil has already appeared or is likely to appear. In all sections the energies of the Bureau have been put forth to encourage better methods of farming, with highly gratifying results.

#### COOPERATION WITH FARMERS.

With a view to bringing directly home to the farmers of Texas and Louisiana, especially those in the boll-weevil districts, the advantages of better methods of cultivation, the value of early maturing seed, etc., the Bureau organized an extensive line of propaganda work. The farmers in the various counties were organized and were brought into cooperation in such a way that large plantings were made under the direct supervision of the Department. Tracts of 5, 10, 15, and 20 acres were handled by individual farmers, under working plans furnished by the Bureau, the object being in all cases to demonstrate the practicability of growing cotton despite the presence of the weevil.

More than 5,000 farmers were engaged in this work, and the results have been highly satisfactory. At a recent meeting held in Houston, where more than 200 representative farmers from all parts of the State were present, records were presented showing the yields of cotton under the plans of the Department compared with old methods. The increased yields, ranging all the way from 25 per cent to 100 per cent in districts badly infested by the weevil, show that by proper methods of culture, the use of early maturing varieties of seed, and the application of proper fertilizers excellent results may be obtained. A complete record of the yields from the various farms conducted under the direction of the Bureau has been kept, and a report embodying these data will soon be published.

#### COOPERATION WITH THE TEXAS AGRICULTURAL COLLEGE.

In the special work on cotton the Bureau of Plant Industry has been in the closest cooperation with the Texas Agricultural College. The president of the college has taken charge of the farmers' institute work, and with the aid of several men selected by him and men furnished by the Department all parts of the State were visited early in the spring, and the necessity for giving strict attention to better methods of cultivation was set forth. This institute work will be continued during the present autumn and winter. In addition to the institute work, the Bureau has been cooperating with the college in the matter of the breeding of cotton, the testing of fertilizers, and other important lines of investigation. Thorough harmony prevails, and every effort is being made by both the Department and college officials to make the work effective.

#### COOPERATION WITH LOUISIANA AUTHORITIES.

Cooperation has also been secured with the Louisiana authorities, and a number of important lines of work have been carried on in the State. The propaganda work, as described for Texas, has also been conducted in portions of Louisiana. Demonstration work with fer-

tilizers has been carried on; also other investigations having for their object the encouragement in every way of better methods of farming in advance of the approach of the weevil.

### DIVERSIFICATION FARMS.

As another feature of the work in the South, plans were made and put into operation establishing diversification farms at various places. The object of these farms was to show the value and importance of diversified agriculture. It was found unnecessary for the Bureau to expend any funds in the development of these farms, except in minor ways for the purchase of certain special seeds, and sometimes for special fertilizers where such were to be used. In all cases the business interests of the respective communities gladly cooperated with the Bureau to the end not only of securing a desirable farm for the purpose, but assuming all responsibility for its support. In every instance efforts have been made in organizing these farms to make them not only self-supporting but profitable. The main object of the work is to show that by diversified agriculture the lands may not only be improved, but more money can be made than in farming with a single crop.

Thirty-two of these farms have been or are about to be established, of which 16 are in Texas, 5 in Louisiana, 3 in Georgia, 2 in Alabama, 3 in Mississippi, 2 in South Carolina, and 1 in Florida. The general method employed in locating, organizing, and conducting these farms is to first determine in what section of the State the various farms are to be located. An effort is then made to find a progressive farmer who is desirous of encouraging diversified farming in his section, and who is willing to permit the Department to aid him in doing it. When a suitable arrangement has been made, a representative of the Department and the State experiment station make a thorough study of local conditions with reference to cropping possibilities, markets, advantages, etc. A system of records is instituted, which enables the Department to secure detailed information regarding every phase of the management of the farm and the results secured. After the farms are established, other farmers are encouraged to visit them, this being done largely through the cooperation of the State experiment stations.

### BREEDING NEW TYPES OF COTTON.

Extensive work has been inaugurated in Texas having for its object the breeding of new types of cotton better adapted to meeting the conditions brought about by the invasion of the weevil. More than 100 varieties of cotton have been grown and many selections have been made. This is necessarily slow work, but already very encouraging results have been secured in the matter of obtaining earlier and better yielding types—types that are better able to resist storms and types for special purposes in several regions.

### DISCOVERY OF THE GUATEMALAN ANT.

During the year an important discovery was made by an officer of this Bureau, viz, the discovery in Guatemala of an ant that destroys the weevil. Eighty-nine colonies of these ants were brought into

Texas and are now being thoroughly studied with a view to determining their value as a means of checking the serious inroads of the cotton insect. After the introduction of the ant by this Bureau further work on its distribution, habits, etc., was placed under the Bureau of Entomology.

### WEEVIL-RESISTANT COTTON.

Another and perhaps more efficient method of combating the boll weevil than by means of the ant has been discovered very recently. The hope of finding a variety of cotton not subject to injury by this pest has been cherished for several years, but hitherto no method has been ascertained by which the plant could offer effective resistance to the insect. It has been found, however, that in some varieties of cotton the presence of the larva, instead of blasting the buds and bolls, often stimulates a special growth of internal tissue which kills the young weevil. This is not merely accidental or abnormal, but is in the nature of a protective adaptation developed as a final result of a long struggle for existence between the cotton and the weevil in tropical America. The insect could not breed or perpetuate itself in the presence of a variety of cotton in which the formation of the new protective tissue occurred regularly. It is accordingly within the range of scientific possibilities that resistant varieties of cotton can be found in tropical America or developed by selection, and work on this line has been begun.

### DISTRIBUTION OF EARLY-MATURING VARIETIES OF COTTON SEED.

With a view to encouraging the planting of early-maturing varieties of cotton, such as King and Parker, a large distribution of these varieties was made in the State of Texas and a portion of Louisiana during the year. Small quantities were sent to farmers, the cooperation of Senators and Members of Congress being secured for the purpose of distribution. Records have been kept of all the farmers who received this seed, and reports are now being returned to the Department as to its value as compared with ordinary sorts. In most cases very encouraging reports have been received as to the use of the early-maturing seeds, and the chief value of the work will be in the fact that from this distribution the farmers themselves may start the selection of stock seed for future planting.

### INVESTIGATION OF THE COTTON ROOT-ROT.

As a feature of the work in Texas a special effort has been made to obtain information as to the best methods of combating the cotton root-rot. This disease has been very serious the past season, destroying large areas of cotton in many portions of the State. Efforts have been made to secure resistant types, but so far the results obtained have not been very encouraging, although some progress has been made. Experiments have been made for the purpose of determining the value of soil treatments, seed treatments, and other methods of combating this disease, including crop rotation. This work has just been started, and it is too early yet to determine its value.

## PROGRESS IN COMBATING PLANT DISEASES.

### CRANBERRY DISEASES.

Important advances were made during the year in the matter of treating cranberry diseases. The cranberry crop is an important one in this country, aggregating in value a million dollars or more annually. In recent years several destructive diseases have caused a great deal of damage, and until the Department began its investigations little progress had been made in the matter of treatment. Experiments the past year in the treatment of one of the most serious diseases, commonly known as "scald," have been quite successful. It has been demonstrated that this particular disease may be prevented by the application of fungicides at very small expense.

### ERADICATION OF LITTLE-PEACH DISEASE.

The efforts made by the Department in the matter of demonstrating the feasibility of eradicating the little-peach disease from the orchards of Michigan and other States have been continued on a large scale. A section 3 miles square in Michigan was selected for this work and the orchards were thoroughly gone over three times during the months of July, August, and September and all of the affected trees were destroyed. The object of this experiment is to demonstrate what is believed to be a fact, viz, that the disease can be entirely eradicated by the extirpation process.

### WINTERKILLING OF FRUIT TREES.

The extreme cold of the past winter caused the extensive killing of fruit trees in many portions of the Northern States. At the approach of spring the trees had the appearance of being seriously injured, and undoubtedly a great many would have been destroyed but for the timely aid rendered by the Department in the matter of suggesting proper means of handling such injuries. A brief report was issued as a guide to the owners of the frozen trees, and this undoubtedly saved many orchards from needless destruction.

### DISEASES OF TOBACCO.

The most serious disease of tobacco in the United States during the past season has been the new malady called "wilt." This has been very destructive in certain portions of the South, and so rapid has been the spread of the trouble that it threatens the complete destruction of the large tobacco industry in North Carolina. Evidence is at hand that this disease is very similar to other wilt troubles, and that it may eventually succumb to treatment through the selection and development of resistant types. Work with a view to securing these types is now being conducted.

### WILT DISEASE OF COTTON.

The success of this Bureau's wilt-resistant varieties of cotton was more marked last season than ever before. An improved selection from the Rivers cotton remained entirely free from the wilt on the worst infected land on James Island, South Carolina, where the finer types of Sea Island cotton are grown. These cottons, originating

through the efforts of the Department, are not only wilt resistant but have a finer and better staple than the original nonresistant strains, thus disproving the assertion that resistance to wilt had been obtained at the sacrifice of quality. Considerable quantities of the seed of resistant and desirable strains of cotton have been obtained and distributed. In connection with this work the wilt of the cowpea has also been studied and resistant types secured and distributed. About 200 bushels of the resistant cowpea seed were sent out last spring. This work is being developed as an auxiliary to the cotton investigations, as it has been found that many thousands of acres of sandy soil in the Gulf States are infected by both the wilt and root-knot, and the cultivation of the ordinary cowpea results in great injury to the cotton.

## ADVANCES MADE IN FORAGE-CROP WORK.

### ALFALFAS AND CLOVERS.

Alfalfa has attracted more attention on the part of farmers in the eastern half of the United States during the past two years than any other crop. The Department has demonstrated that it can be grown in almost every State in the Union. Varieties have been found which withstand the rigorous winters of the northwestern prairie States. Other varieties have been found which are immune to the alfalfa leaf rust. There is still much to be learned concerning the adaptability of alfalfa to various types of soil in the Eastern States, and much time is being devoted to the solution of this problem. The cultural methods required for establishing and maintaining alfalfa meadows are also receiving due attention. The subject of clover sickness, a matter of very great importance to farmers throughout the clover region, is being investigated. New varieties of clover which appear to possess some advantages over the standard varieties grown in this country have been secured and are being propagated with a view to introducing them generally in the clover region as soon as sufficient seed is available. Some of our native clovers are being grown under farm conditions in order to determine whether or not they are worthy of domestication. One or two of them are promising, particularly for sections of the country where red clover does not thrive.

### SOIL AND SAND BINDERS.

Methods of holding drifting sand in place have been thoroughly worked out. An agent of the Department has made a careful study during the past two years of the methods which have been developed in Europe in work of this character, and demonstrations of these methods are now being made in portions of the country where drifting sand is most troublesome. Attention is also being given to plants adapted to hold banks and the sides of cuttings in place, and several plants which possess high value for this purpose have been found. This work is of particular interest to civil engineers, and in prosecuting it the most hearty cooperation from them has been received.

### RANGE INVESTIGATIONS.

During the past year a large amount of information regarding the carrying capacity of the ranges in various parts of the West has been collected. The fact that intelligent management will bring the ranges

back to their primitive state of productiveness has been established. For two years past an area of fenced range in Arizona, in which all types of range land are represented, from absolute desert to good mountain range, has been under careful observation. Two years' protection from stock has sufficed to make this range nearly as productive as it was in its virgin state. The methods of management used by parties who own or control considerable areas of range land are being studied. It is considered to be definitely demonstrated that there is no chance of improving range conditions except where stockmen are enabled to control the ranges upon which their stock feed, and data are being collected which will furnish valuable information as a basis for legislation concerning range lands. It has been demonstrated that a number of species of plants may be introduced upon the ranges by practicable means.

In nearly all cases the plants which have been of value for this purpose are annuals producing large quantities of seed. The possibility of introducing other plants upon the range is still being investigated. In this connection a careful study of the large collection of annual grasses from Europe in our extensive herbarium is being made, with a view to finding species which appear to be adapted to conditions on our Western ranges. Arrangements have been made whereby seed of some of the most promising of the species may be secured for use in the investigations of this subject. It has been demonstrated that in the mountain ranges where there is considerable rainfall a number of standard grasses and clovers may be established upon the range by methods that are entirely practicable. In the mountain region in the State of Washington, by protecting the range from the depredations of nomadic herds of stock, the Bureau has been able to establish such grasses as timothy, redtop, bluegrass, and white clover, thus adding enormously to the productive capacity of these ranges. During the year much assistance has been rendered to ranchers by outlining methods of handling their ranches.

### THE CACTUS AS A FORAGE PLANT.

Much of the range country is covered with a sparse growth of cactus, which for the most part is looked upon by stockmen as a nuisance. During the past year a number of methods have been found by which the cactus plant may be utilized to advantage as stock feed. The value of the more promising species for forage purposes, the length of time required to mature a crop of cactus on land from which the old growth has been harvested, and the feasibility of establishing cactus plantations where they may be needed are now being investigated.

### ALKALI-LOVING PLANTS.

The increase of the area of alkali lands in the irrigated districts of the West has given added importance to plants that may be grown upon such lands. Several such plants are available, and the Bureau is investigating the forage value of these plants, as well as methods required for their cultivation. A few years ago the Australian saltbush was shown to be adapted to lands of this character, and a great deal of interest in this plant was aroused among Western farmers. Recent investigations by the Bureau indicate that the cultivation of the plant

has practically ceased. There is no question of the value of the Australian saltbush as a forage plant or of its adaptability to strong alkali lands. The principal difficulty with the plant seems to be that proper methods of utilizing it have not been worked out. The Bureau has undertaken to find what place it can be made to occupy in Western agriculture and the methods by which farmers can take advantage of its demonstrated value. Considerable areas of a number of other forage plants known to be adapted to alkaline conditions are being grown with a view to determining their forage value.

### INVESTIGATIONS OF GRASSES, FORAGE PLANTS, AND STOCK FEEDING.

The office of Grass and Forage Plant Investigations is now in possession of the varieties of timothy developed by Dr. A. D. Hopkins. Some of these are greatly superior to timothy as ordinarily grown by farmers. They are being propagated with a view to making the seed available, which it is hoped will be within two more years.

Mr. A. B. Leckenby, director of the Eastern Oregon experiment station, has kindly turned over to this office 23 varieties of *Bromus inermis* secured by him during the past two years. These are being grown with a view to rendering the best varieties available for distribution.

The separation into varieties of such standard grasses as redtop, Bermuda, orchard grass, and meadow fescue has been undertaken. Work of this character already done indicates that all of our standard grasses are really mixtures of a large number of established varieties. Some of these varieties are much superior to the grasses ordinarily grown. It is hoped within a few years to be able to offer farmers small quantities of seed of improved forms of all the standard grasses.

### WEIGHT AND VOLUME OF HAY.

The office of Grass and Forage Plant Investigation has shown that the ordinary rules in vogue for determining the volume of hay in the stack are not reliable, and it has developed formulæ that give reliable results. It is now investigating the number of cubic feet of hay per ton for hay under various conditions as to kind of hay, size of stack, and length of time it has been in stack.

### DOMESTICATING NATIVE GRASSES.

A considerable number of native American grasses have shown themselves to be adapted to regions where at present hay grasses are wanting. Several of these are being grown under field conditions during the present season with promise of success. The Bureau is gathering a considerable quantity of seed of other grasses this year and will give them a trial, particularly in the semiarid portions of the West, at the earliest opportunity. It is believed that hay grasses can be found for the Western plains where the average annual rainfall does not exceed 15 inches.

### WINTER PASTURES FOR THE SOUTH.

It is estimated that during the past winter one-third of the range stock of some of the ranges in Florida perished for lack of proper

nourishment. The winter being severe, losses of range stock were common in all parts of the South. It has been demonstrated that a number of plants can be made to furnish satisfactory pasture throughout the winter months in the South. During the past year a large amount of information concerning these plants and their adaptability to different soils, and the cultural methods required for their successful growth, has been collected. During the present season it is planned to cooperate with Southern experiment stations and Southern farmers in testing a number of these plants for winter pasture purposes.

GULF COAST CROPS.

The agrostologists of the Bureau are studying the forage value of the velvet bean, beggar weed, Mexican clover, and cassava for the region adjacent to the Gulf of Mexico, to which our standard forage crops are not adapted. They have shown that a well-nigh perfect stand of cassava can be obtained by germinating the canes in a cold frame or hotbed before planting them in the field. Heretofore the methods used produced ordinarily not more than half a stand of this crop. Methods of keeping cassava canes over winter are still being investigated. These investigations indicate that the most important factor in keeping the canes is maturity. It is extremely difficult to prevent decay of partially matured canes during the winter months. Forty-two varieties of cassava have been secured, one of which last year produced seed in southern Mississippi, although planted nearly two months later than the best planting season. This year one plant was grown from this seed. It seems probable that some of these varieties may be made to thrive considerably farther north than cassava has yet been grown.

FORAGE CROPS FOR SOUTHERN FLORIDA.

The development of truck farming in southern Florida has rendered urgent the need of forage crops for the work-stock used on the truck farms and for the dairy cattle which supply milk to the numerous hotels. Feed for this stock is now shipped long distances at great expense. It appears that Guinea grass and Para grass are adapted to climatic and soil conditions in that section and their possibilities for this purpose are being investigated. Guinea grass seems to possess particular value for hay production, while Para grass appears to be promising as a pasture grass, particularly for wet muck soils. The Bureau is preparing to give them an extended trial.

PACIFIC COAST PROBLEMS.

The office of Grass and Forage Plant Investigations is searching for forage crops to grow in alternation with wheat in order that farmers in the great wheat regions on the Pacific coast may be enabled to secure more than one crop every other year on their fertile lands. A number of grasses are also being studied with reference to their adaptability to dry lands in that section, where there are many thousands of acres of land too dry for any of the standard forage crops.

JOHNSON GRASS.

The agrostologists of the Bureau have demonstrated that the formidable pest known as Johnson grass may be completely destroyed

by practicable means and that it may easily be held in check. They are now making demonstrations of the methods developed in their investigations and are endeavoring to devise an implement for removing Johnson grass rootstocks from the soil.

### SOILING CROPS.

With the development of stock farming and more intensive methods, particularly in the eastern half of the United States, the practice of soiling is becoming more important. Farm practice with reference to soiling crops is being studied with a view to formulating systems for all sections of the country. In this, as in all investigations, the experience of successful farmers has been of great assistance.

### CROPS FOR OVERFLOWED LANDS.

The problem of utilizing lands subject to annual overflow has continued to receive attention. Particular attention has been given to short-season annual crops, such as millet, early varieties of corn and sorghum, buckwheat, cowpeas, soy beans, and rape, for lands that are free from water during midsummer and the fall season, and all these crops have been grown successfully on land that was covered with water until the latter part of June. The native grasses which are extensively cut for hay on overflowed and swamp lands are also being studied with a view to making seed of some of the best of them available on the markets, so that farmers who are in need of such grasses may be able to obtain their seed.

### FRUIT-MARKETING INVESTIGATIONS.

Next in importance to ability to produce choice fruits is the existence of a sufficient demand for them at prices that will yield a fair profit to the grower. In fact, without reasonable assurance of market demand for the product at fair prices, the planting or maintenance of commercial orchards or vineyards is folly. From the nature of their product, which is at the same time perishable and an article of luxury rather than of absolute necessity to the average consumer, the prosperity of our fruit growers is more dependent upon the price of their product at the time of harvest than that of almost any other agricultural class. Glutted markets at such times are peculiarly disastrous both to individual fruit growers and to the regions in which commercial fruit culture has become an important feature of agriculture.

The avoidance of gluts is, therefore, of very great importance to the entire fruit industry. While many remedies have been suggested, that which appears most practicable and reasonable is the wider distribution of the product. For this reason the chief line of investigation in fruit marketing has been the determination of methods best adapted to the harvesting, packing, storing, and forwarding of fruits to points relatively distant from their places of production, with a view to developing wider demand for them, both in the United States and foreign countries. Chief attention has been thus far given to problems connected with the development of the trans-Atlantic export trade, the most important work having been done with summer and winter apples, peaches, and pears.

matter of securing new and desirable long-staple cottons. During the last three years a number of long-staple Upland varieties of cotton have been originated, and these have come to be cultivated to some extent in certain parts of the cotton belt, and very generally in the rich bottom lands of the Mississippi and Red rivers in Mississippi, Arkansas, Louisiana, and Texas. A large number of hybrids have been made for the purpose of securing Upland types of long-staple cottons, which can be put into general cultivation, and which will be superior to those now in use. Several of these hybrids are approaching fixity of type. Among these are some having a staple from 1¼ to 1⅜ inches in length.

In the breeding and improvement of corn important advances are being made. The main object of this work has been the selection of strains of corn best adapted to the different sections of the United States. The work is being conducted in cooperation with twenty or more State experiment stations and many farmers. Each year the Department obtains pure seed from the originators and breeders of the leading strains of corn in various sections of the country, and is sending this seed to different localties for comparative tests. At the same time extensive hybridization work is proceeding for the purpose of securing sweeter, more tender, and more productive strains of sweet corn for table use. Connected with this work, also, there are being studied problems relating to the handling of seed corn, seed selection, etc.

Extensive breeding investigations of oats have been carried on, mainly for the purpose of producing a profitable variety for the rich farm lands of the great corn-growing States, where oats are used in rotation with corn. The production of a more desirable oat for meal constitutes a part of this work. Some very promising hybrids have been obtained from the naked oat of China—the so-called "European hull-less oat."

In the improvement of potatoes important work has been conducted along two lines—(1) type selections, and (2) the production of new seedling varieties. This work was begun in 1902, and already very promising results have been obtained, especially from some of the hybrids.

Some of the most important investigations in the matter of breeding and selection have been inaugurated in connection with the growing of tobacco. This work is conducted along two principal lines—(1) the selection of individual types in the varieties, and (2) crosses between different varieties. Extensive work has been carried on in Connecticut, where both shade and outside tobacco are grown. The work conducted so far has shown unquestionably that the desirable characteristics in the leaf can be fixed from the first year's selection. In this work nine different types have been used and more than 300 selections have been made of each type. One hundred and twenty-five plants are used as a standard for each selection. Thus the work of selection alone has involved the use of something over 40,000 plants.

The work has been conducted in such a way that all the plants have been grown under tent shade, and the entire development of the leaf, from the seed bed to the manufactured product, can be followed. Allied with this work extensive investigations have been made as to the effect of hybridization. Hybrids are easily secured, and from the evidence already obtained by experience in the Connecticut Valley it is believed that the improvement of tobacco by crossing is practica-

ble and can be successfully carried out according to plans now in operation.

Other important lines of work, having for their object the securing of new types of grains, fruits, and other crops, have been carried on. Important work has been done in the matter of developing new varieties of pineapples, new varieties of pears, and other fruits.

### PROGRESS IN SEED AND PLANT INTRODUCTION.

The work of introducing and establishing new plants from foreign countries has resulted during the year in the introduction of 1,429 selected kinds of seeds and plants. These have been secured through correspondence and by means of our agricultural explorers, one of whom was sent to the Russian Caucasus in search of new varieties of fruits; one to the West Indies for tropical cassava; a third made an extensive study of the European flax regions, and a fourth visited Mexico in search of southern country apricots. Such a large number of plants, introduced during previous years, remained to be adjusted to American conditions that the efforts this year, more than last, were concentrated on the domestic side of the problems, and no very extensive exploring trips were undertaken. Notwithstanding this, however, a number of new important importations were made. A shipment of over 350 date suckers, representing 42 varieties, mostly new to America, was made from the oasis of Biskra in the Sahara. Two hundred and seventy samples of different strains of European flax were collected. A collection of 19 selected varieties of grapes from the Russian Caucasus was arranged for. Two hundred and fifty pounds of seeds of the true pistache and smaller quantities of seeds of related species for stocks were imported from Turkey and Central Asia. Thirty-three varieties of mangoes of recognized superiority were secured from Central India in Wardian cases for Florida cultivators.

A shipment of 157 bushels of berseem was made from the valley of the Nile. Two thousand pounds of the famous pedigreed Hanna barley were secured from its originator in Moravia. Two hundred trees of the hardy Vladimir cherry, for trial in the Northwest, were imported from Russia. One hundred and five varieties of French phylloxera-resistant grapevines were secured for trial in infested California vineyards. New species of the lily, from the Philippines and the Neilgherry hills of India, were introduced for breeding purposes. The yang-taw, from Central China, an entirely new fruit-producing vine, was presented to the Department by Consul Wilcox, of Hankow. A number of promising resistant South African grapevines, a collection of Canary Island plants, some East African sorghums, and an interesting clover from Uganda were some of the gifts of Mr. Barbour Lathrop, whose expeditions in search of plants for this Department have been mentioned in previous reports.

Many of the important introductions from previous years still occupy the attention of the office, and either require fresh material from abroad or necessitate field experiments. The durum wheat area has been greatly extended, as already noted. A new date garden in the desert region of southern California has been established in cooperation with the State experiment station. The Egyptian cotton introductions are leading to the production of new hybrid races of

promise. The Malin or Moravian horse-radish has proved a success. Japanese bamboo and Mitsumata paper plantations are being arranged for. Tropical mangosteens, imported by post, are being successfully propagated for distribution in Porto Rico and Hawaii. Egyptian clover is being given an extensive trial in Texas, Louisiana, and California. A new seedless pomelo from Siam has been grown for distribution. The Turkestan alfalfa has seeded in several localities, and the securing of American-grown seed of this variety is now a possibility.

### CONGRESSIONAL SEED DISTRIBUTION.

As pointed out in my previous reports, constant efforts are being made toward the improvement of methods of securing and handling the general seeds for Congressional distribution. Improved appliances have been perfected for the mechanical work, and improved methods have been adopted for securing the seed. The work is now all under the direct supervision of efficient officers of the Bureau of Plant Industry. Every effort is being made to improve the quality of the seed by securing pure stocks. Extensive work is being conducted in the matter of a critical study of varieties under different conditions of soil and climate. Testing gardens for this purpose have been established in a number of localities, and the work is under the supervision of a thoroughly competent expert horticulturist. Every effort is being made to encourage home seed growing. Practically all of the vegetable seed now distributed by the Department is grown in the United States.

A few years ago nearly all of the flower seed, except sweet peas, was imported. Now fully 75 per cent is grown here, through the encouragement offered by the Department in this work. A special effort is put forth in the matter of distributing promising varieties of cotton, tobacco, forage crop, and other seeds. The cotton experts of the Bureau have been constantly at work securing new and desirable sorts wherever they have been found in connection with the other cotton investigations. The results of this continuous distribution of improved strains are already beginning to show in a number of sections of the South.

In the handling of this enormous work which Congress puts upon the Department, the necessity for strict business methods has been fully observed. The work of handling one branch only of this problem involves the securing of more than 25 carloads of special seed, and the testing, packeting, and mailing of this large quantity to all parts of the United States. The systematizing of all the operations has been so perfected that there is little or no friction at the present time.

### NITROGEN-FIXING BACTERIA.

Extensive practical tests were made the past season with nitrogen-fixing bacteria for use in connection with leguminous crops. The results have been even more successful than we had anticipated. Hundreds of applications have been sent in from every State in the Union for material with which to inoculate various crops. Practically all of these requests have been complied with in such a way that a record of the results could be obtained. The results show conclusively that where the organisms are used in accordance with the directions issued

by the Bureau increased yields, ranging from 15 to 35 per cent, are secured. Furthermore, many farmers have been successful in getting stands of clovers and other crops on soils where failure has resulted heretofore. The several strains of bacteria sent out from the Department have proved valuable even on soils containing the uncultivated organisms in abundance. It was discovered during the year that tubercle formation is not necessary to successful inoculation.

The bacteria can be present in the roots of legumes in a very efficient state with no tubercle formation whatever. The material for inoculating an acre of soil by the methods which have been developed costs the Department about 1 cent per acre and the farmer scarcely anything to apply it. So great has become the demand for this material that private concerns have become convinced that there is profit in preparing and distributing it, and several firms are now announcing their preparedness for doing this. Widespread interest in the subject has been manifested by the agricultural press and the magazines, and as a result of this propaganda work the demand for the organisms is constantly increasing.

### INVESTIGATION OF PLANTS POISONOUS TO STOCK.

In parts of the Northwest where sheep grazing is an extensive industry, very great losses have been experienced in many sections, due to the so-called "loco disease." This disease is commonly attributed to the eating of the loco weed, by which parts of the range are almost monopolized. In one county in one of the Northwestern States in which sheep grazing has been the chief industry, the disease has made such inroads that many stockmen have been obliged to give up sheep grazing altogether, with the result that land values have depreciated and the sheep from this region are viewed with suspicion by buyers.

During the past two years investigations have been made to test the relation between this devastating trouble and the so-called "loco weed" prevalent in this section of the country.

### FIBER PLANTS.

The textile industries using plant fibers have been growing, with lcineased demand for twine, cordage, and woven goods, but, with the exception of cotton, the production of plant fibers in this country has not kept pace with the consumption. The raw fiber imported during the fiscal year ended June 30, 1904, was valued at more than $47,000,000. This amount included about $9,000,000 worth of cotton, chiefly Egyptian and other grades, not produced here commercially. The other fibers imported were mostly sisal, manila, jute, flax, istle, and hemp. Investigations of all these fibers have been conducted by the Bureau, special attention being given to those likely to succeed in our own country.

### DRY-LAND AGRICULTURE.

In my last annual report attention was called to the importance of developing a system of agriculture adapted to the semiarid areas of the United States where general irrigation for ordinary crops is not practicable or possible owing to the small annual rainfall and the consequent lack of sufficient water. This is true of nearly one-fourth of

the entire arable land surface of this country. It is believed, however, that a profitable system of agriculture can be developed for these areas by securing crops which will grow with a very small amount of water. Considerable progress has been made in this direction and facts have been secured which show the necessity of an immediate and thorough investigation of the conditions affecting the moisture requirements of crop plants for growth in semiarid regions, such as Kafir corn, alfalfa, drought-resistant wheats, and other crops at present unknown to American agriculture.

### WATER PURIFICATION INVESTIGATIONS.

Attention was called in my last report to the investigations being carried on by the physiologists of the Bureau of Plant Industry with a view to finding methods of destroying obnoxious algæ in water supplies. The method discovered consists in using extremely dilute solutions of copper sulphate. After a chemical and microscopical study of the water to be treated, and identification of the contaminating organisms, the amount of copper required to be effective is determined and introduced in the form of sulphate. Numerous tests have been made in cooperation with boards of health and water engineers in a number of large reservoirs, and the method has proved remarkably efficient and successful. The fact that one part of copper sulphate to one hundred thousand parts of water will at ordinary temperatures completely destroy the bacteria causing typhoid fever and Asiatic cholera suggests the great usefulness of copper in fighting these diseases and other maladies caused by closely related organisms. Physicians and public health officials have taken great interest in this work, and will doubtless make prompt and thorough tests of the usefulness of copper in such cases.

### CONSTRUCTION OF NEW GREENHOUSES.

The new buildings planned for the Department made it necessary to remove the glass houses now on the grounds. A special appropriation of $25,000 was secured for this purpose, and the new houses have been erected and are now complete. This new range consists of 8 modern houses, each 142 feet long, which were put up under contract. Three additional houses have been put up by the Bureau's force of workers, and two of the smaller houses have been moved from their old location to the new one. The new range is much more satisfactory than the old one, and it will be devoted to various lines of work connected with the Bureau. The contract for the new houses was let on June 1, 1904, and they were completed on September 1 of the same year.

### ARLINGTON FARM.

During the year the important work of improving the soil conditions at the Arlington Farm has been continued. New systems of drainage have been put in, cottages for the superintendent and other workers constructed, barns erected, and other improvements made; and the farm has been put in shape for the advanced experimental work it is proposed to conduct there. Extensive plantings have also been made of economic fruits, ornamental trees, and other plants.

Test work with potatoes, celery, forage crops, and various fruits has been carried on. Cooperative work with other bureaus has also been inaugurated.

### COOPERATION WITH STATE EXPERIMENT STATIONS.

The Bureau of Plant Industry is now cooperating with practically all of the State experiment stations in the country. The work covers investigations of diseases of plants, studies having for their object plant improvement, investigation of forage crop conditions, encouragement in the production of new crops and new industries, and many other lines of work. In some special cases, notably California, close cooperation has been effected, having for its object the establishment of important testing gardens and other allied work. With the assistance of the officers of the California experiment station a testing garden has been established at Chico, Cal. The land for this garden has been donated to the experiment station, to be held in trust by the station for the use of the Bureau.

It is planned to carry on extensive work here in the matter of testing grains, fruits, and other crops specially adapted to the Pacific Coast. It is the policy of the Department in all cooperative work with the stations to fully recognize the relations of the stations to the officers who control them. Furthermore, wherever the Department desires to undertake work in a State, its policy is to endeavor to do this work in cooperation with the station.

### FARM MANAGEMENT.

In order to properly conduct the work on farm management, which has already been set forth in previous reports, an office has been established for the purpose. The object of this office is to bring together in systematic shape all of the available information in the Bureau in such a way that it can be placed in the hands of the farmer for his practical use. The office gathers together information concerning farm practice in all sections of the country as a basis for further work. It secures and publishes correct records of crops grown and the manner of growing them, for the information of others who desire to follow successful plans. It encourages farmers to visit and study experiment station work, the experiment stations, and the successful farmers in their own section. It encourages diversification in farming where continuous, clean cultivation of a single crop has impoverished the soil. It outlines systems of cropping for different kinds of farming in all sections of the country, and furnishes data in the matter of properly laying out farms, fruit plantations, truck gardens, etc.

## BUREAU OF FORESTRY.

### PRESENT FOREST SITUATION IN THE UNITED STATES.

The present outlook as regards forestry in the United States is exceedingly hopeful. The lumber industry as a whole is now awakening to the fact that lumbering with reference to future as well as present profits may be good business and ought to be taken into account on business grounds. A growing tendency to hold cut-over

lands is plainly marked among far-sighted owners of large holdings. This means that conservative management on the part of those who operate on a large scale is fairly launched. Except that further agitation is essential to give the facts publicity, the general adoption of forestry as an established policy now depends primarily on business conditions pure and simple. The question whether or not it will pay is one to be settled in each individual case by study of conditions on the ground. Forestry can not alter economic conditions; it can only use them. Forestry is now in actual practice on large, privately owned tracts in seven different States. This is the direct result of the past work of this Department in forestry.

## FIELDS FOR FUTURE WORK OF THE BUREAU.

### NEED OF INVESTIGATING GENERAL FOREST PROBLEMS.

Extensive investigations of forest conditions and of methods of operation are still urgently needed before the road to practical success can be said to be generally open. The employment of foresters by large private owners to supervise operations on their own lands is being taken up. In the public interest this needs to be brought about wherever conditions are favorable, but more and more the promotion of private forestry by the Bureau of Forestry can and should be made incidental to its other functions of directing the management of public forest lands and scientifically investigating general forest problems.

In the case of small owners much remains to be done. The farmers of the country are learning how to get the most out of their land in other ways through the scientific information which the Department of Agriculture collects and diffuses. So, also, in the case of timber yield, studies which individuals can not undertake but which must be made if the wealth-producing power of the country as a whole is to be brought to its highest point, need to be prosecuted in the public interest. The average small timber-land owner is to-day in many parts of the country a a decided disadvantage in comparison with the large owner, because he lacks both working capital and equally broad knowledge of general conditions. It is true that large lumbering operations can often be made more profitable than small, but it is not in the public interest that small owners should fail to make a profit which is within their reach because they do not know how best to utilize what they have now, or do not realize what it is likely to be worth in the future. Thus the furtherance of that part of this Department's work which is directed toward informing the small owner how he can to advantage practice forestry on his own account, is of the first importance for the best use of the 200 million acres of woodlots which our country contains.

### SCIENTIFIC STUDIES AND AID IN CARE OF STATE AND NATIONAL FORESTS.

By its scientific studies of American forests the Bureau of Forestry has prepared a solid basis for practical forestry. Special studies of our important timber trees have yielded information obtainable in no other way and essential to the management of forests of which they form an important part. There is now no considerable portion of the United States for which the Bureau of Forestry has not at hand special

knowledge bearing directly on questions pertaining to the use of the forests. Nevertheless, what has been done is hardly a beginning in comparison with the vastness of the field.

In the work of building up a sound permanent policy for the forests of the National domain the Department of Agriculture has continued to render important services. Much of the work of the Bureau of Forestry during the year has been the examination of lands already reserved or likely to be reserved in order to recommend the exclusion from them of such areas as are more valuable for agriculture than under forest. The personnel of the Bureau of Forestry has become practically familiar, by studies on the ground, with every phase of the question of putting to the best use the public lands of the country. Thus an efficient force has been prepared by actual experience, as well as by technical, scientific training, for the demands which a fully developed National forest policy must eventually impose.

In the light of these facts it is plain that the ultimate function of the Bureau of Forestry as a part of the Government administrative equipment is gradually defining itself. Its effort to introduce forest management among large private owners at the earliest possible moment will cease to be necessary when it becomes generally successful. It was undertaken because of an evident urgent public need. Destructive lumbering had already greatly reduced the area of productive timber lands in the United States, and its continuance was a menace to the future prosperity of the country. Because of the work of this Bureau forestry has now a recognized standing in the eyes of the American lumber trade. The Bureau of Forestry is giving a smaller proportion of its time to the preparation of working plans for large timber tracts belonging to private owners than ever before, and bearing a smaller proportion of the expense, and the progress of the past year has brought visibly nearer the time when it can withdraw practically or entirely from this field.

There will then chiefly remain work along the lines of (1) scientific study of problems which have a practical bearing on forest utilization for any purpose; (2) cooperation with States which ask advice concerning forest legislation, administration, or the formulation of a State forest policy, and (3) the discharge of whatever duties may be assigned to it in connection with the administration of the public lands by the National Government.

Along this latter line it is at present the official adviser in technical matters of the Departments which have in charge forested lands under Government control, both here and in the Philippines, and it is also chiefly responsible for recommending changes in present reserve boundaries and for recommending the setting aside of new reserves. The policy which lies at the base of the creation of the reserves is that the public forests should not be withdrawn from use, but should be managed under such restrictions as will insure their permanent usefulness. This policy this Department is actively furthering, and no part of its work is more important.

### LINES OF WORK REQUIRING EXTENSION.

An increase in the funds available for the Bureau of Forestry is essential to make it possible to push its work more rapidly. It is my purpose to provide the fullest facilities for the prompt investigation

of actual or proposed forest reserves, as well as for further examinations of forested parts of the public domain not now reserved which give promise of permanent value as sources of water or wood supply. The greatest need of the West is water. In many States future settlement and prosperity depend absolutely upon its conservation. This again largely, in many cases wholly, depends on the preservation of the forests. To make possible the execution and extension of the work, I have asked for an increased appropriation for the Bureau of Forestry for the coming year.

PLANTING ON FOREST RESERVES.—The work of planting on forest reserves opens another fruitful field. In the San Gabriel Reserve in California, the Pikes Peak Reserve in Colorado, and the Dismal River Reserve in Nebraska, the planting has been begun and should be vigorously prosecuted. In the first two cases the object is to cover denuded mountain slopes with forest growth, in the interest primarily of water conservation and, in the case of the Nebraska reserve, to provide a future valuable timber supply. This planting is undertaken only after a careful preliminary survey has proved that there is an economic need for new growth which nature can not supply, and after painstaking experiment has demonstrated what methods can be depended on for success. Under these circumstances expenditure for planting is as truly economical as is that of the farmer when he purchases seed to sow that he may harvest the increase. I believe that an addition to the sum available for this work will be amply justified by the returns.

The development of economic mining will soon wait for the growth of trees within reasonable distance. The miner is an important factor in the growth of many of our States and of the country at large, and should have all facilities given him to conduct his work on the most economic basis. Where the miner ceases work the farm and factory lose a market. For this reason the miner should have the first claim on the forest for such timbers as he requires.

STUDIES IN FOREST PRODUCTS.—Auxiliary to studies of the forest itself, but of the most importance in relation to the conservative use of our forest resources, stand the studies in forest products. Among them at the present time are (1) the studies in timber preservation, especially of railroad ties, which promise such conspicuous and successful results in timber economy; (2) the experiments in timber testing, to ascertain, under such conditions as obtain in actual everyday practice, new strength determinations for use by engineers, architects, and others; and (3) the investigations of the tannin content of barks, of pulp processes, etc. In the way of securing large economies by a comparatively small outlay for investigation, no more promising field for useful work by the Bureau of Forestry is open than this.

COOPERATION WITH STATE AUTHORITIES.—The desire of State authorities for the assistance of the Bureau of Forestry in cooperative work and in framing forest legislation and their willingness to contribute to its cost are facts worth noting. State cooperative studies have now been made in Maine, New Hampshire, New York, Maryland, Michigan, Wisconsin, California, and Hawaii. Were this Department prepared to push the work along this line large results could be rapidly secured. The whole cause of forest preservation hinges on the interest of the State governments, because no matter how fully persuaded the private owner may be that forest management promises

to yield him good returns, without fair assurance of safeguard against fire and of equitable taxation during the period required for a second crop to mature on cut-over lands, he can make no headway. The exclusion of fire depends on local sentiment, State legislation, and State or local police and patrol. Unless the States are awake to their duty toward this form of property the Federal Government can do little beyond caring for its own holdings. In California one result of the cooperative work now going on is the drafting of what appears to be the best forest-fire law yet drawn up in this country. The way is now open for a great advance through State cooperation if the requisite means of meeting its cost beyond the State contributions can be made available.

### SUCCESS OF FORESTRY WORK.

The successive advances which have been made by Congress of recent years in the appropriation for the Bureau of Forestry offer one of the best evidences of the commendation which its work has received. More and more money has been given to it to spend because it has proved year by year its capacity to do more, and more practical, good work. It prosecutes its researches solely that it may discover and diffuse information which contributes to our National well-being. Within six years its force has increased sixteenfold and its expenditure twelvefold; but neither of these facts is an adequate measure of its advance in practical efficiency or of its success in changing former conditions. By a single discovery—that the cup and gutter system, devised by one of its agents, could be commercially applied to the production of crude turpentine—it is now saving many times more annually to the naval-stores industry than the total expenditures of the Bureau during the whole six years.

It has changed forestry for business returns in the United States from an undemonstrated and doubtful theory into a well-established business operation; it has converted the lumber industry of the country from an attitude of well-grounded suspicion to one of support; it has converted the general public from indifference to what seemed an impractical outcry to an intelligent comprehension of what forestry has to offer. By bringing home to the railroads the need of economic utilization, preservative treatment, and provision for future supplies it has set on foot a movement of incalculable importance. By teaching Western farmers how to plant and grow trees for farm protection and local timber supplies it has added materially to the comfort and prosperity of vast regions and many States. More important still, by demonstrating the capacity of the forest to store water, and by energetic activity to guard from sale or destruction forests of important protective power, it has contributed to the success of National irrigation, one of the most vital developments of recent years.

But though this Bureau has accomplished and is accomplishing practical results out of all proportion to its money expenditure, this is not exceptional in the Department of Agriculture, and forms in itself no justification for a further increase. The question is simply in each case whether the country will be better off by spending the money or by not spending it. There are, however, certain special reasons why the Bureau of Forestry should have made, and should for some time continue to make, an exceptionally rapid growth. Its task is virtually that of building up a new science in this country, combined with that

of getting its discoveries recognized and applied by a public once little alive to their value. No other branch of agricultural science has recently been in such need of development, and in the whole history of agricultural progress I believe that no other similar development was ever more timely. This development took place because of the unparalleled National need created by the vastness of the interest involved and the critical point which forest destruction had reached. And there is still much to be done before this new science can overtake the nation's requirements.

## WORK ACCOMPLISHED DURING THE YEAR.

### COOPERATIVE STATE FOREST STUDIES.

Forest studies in cooperation with State or Territorial governments were carried on during the year in New Hampshire, Maryland, Wisconsin, California, and Hawaii. A report on the work in New Hampshire is now in the hands of the printer. It contains a thorough study of the main forest resources of the State, and will afford a satisfactory basis for the adoption of a broad and far-sighted State forest policy.

The study in Hawaii resulted in the publication of a bulletin on "The Forests of the Hawaiian Islands," in the adoption by the Territorial government of its recommendations, and the appointment of a member of the Bureau of Forestry as superintendent of forestry in the islands.

A map and report embodying results of the work in Maryland will appear in the annual report of the State geologist.

In California over 20,000,000 acres of forest were mapped and described; the growth of planted eucalypts was studied; important investigations of the effects of chaparral cover on water conservation and on the forest, and of the forest replacement on denuded areas, were prosecuted; and the study of forest fires was continued, with the result that what is believed to be the best fire law ever prepared for State enactment has been drafted for presentation to the legislature.

### FOREST MEASUREMENTS.

Of forest measurements there were handled during the last fiscal year the results of over 24,000 acres of valuation surveys, over 33,000 analyses of trees, 16,000 height measurements, and 2,300 taper measurements. The volume of this work does not, however, measure its importance. In computing, compiling, and digesting the mass of information supplied by the field studies of the Bureau the accumulation of details would count for little if the results were worked up by purely routine or mechanical methods. The task imposed is to create a body of scientific knowledge by developing to significant conclusions the raw material turned in—a task calling first of all for intelligence and insight. The result is real advance in accurate knowledge of forest conditions and increasing ability to direct practical operations. Both in the preparation of working plans and in the special studies of commercial trees and forest problems which have been made during the year the efficiency of the work included under forest measurements has been demonstrated.

FOREST MANAGEMENT.

The work of the Bureau under the act of Congress of June 27, 1902, known as the Morris bill, has proved that conservative lumbering under practical regulations pays in the white-pine region of northern Minnesota. In point of fact a higher price was obtained for the timber sold under that act, to be cut and removed under rules prescribed by the Forester, than similar adjacent timber brought shortly before, when sold without such restrictions. On about one-fourth of the 200,000 acres to be lumbered the 5 per cent of timber to be left standing had been selected and marked at the end of the fiscal year.

During the year applications for assistance in introducing forest management on private holdings were received from 47 owners of large tracts, covering nearly 4,000,000 acres, and from 89 owners of woodlots with a total area of about 6,600 acres. The field work for eight working plans for large tracts, covering about 1,000,000 acres, was completed, and for 68 woodlots of nearly 19,000 acres total area.

The eight working plans for large tracts were studies of typical problems in five widely separated States. In Minnesota a tract of land formerly covered mainly with white and Norway pine, a large part of which has been lumbered and is now entirely unproductive, presented a characteristic example of much of the remaining forest land of the lake region. The plan of management devised provides for reproduction from seed trees and for fire protection. In Alabama a working plan was prepared for two forests of virgin longleaf pine, owned by one company, which wished to be assured of a continuous mill supply. In Texas another longleaf-pine study completed during the year furnished the material for estimating present and future yields of longleaf and at the same time demonstrated the wastefulness of some of the lumbering methods now commonly followed.

In West Virginia a tract covered with hardwood, hemlock, and spruce forest, much of which is in poor condition, was studied to ascertain the practicability of management. In New Hampshire three working plans were prepared: one for a tract where the requirement was primarily the improvement of a forest-park property; the second for the tract of a manufacturing company wishing to secure a steady supply of box boards and increase the productiveness of the forest; and the third for a White Mountain tract, where the chief requirement was a system of fire protection.

Commercial tree studies of the year included balsam fir, paper birch, poplar, loblolly pine, and red gum.

DENDROLOGY.

Reports which mark the conclusion of the field studies of Missouri swamp forests and Ohio hardwood forests, and of the laboratory studies of gums, resins, tan barks, and pulp-wood fibers conducted in cooperation with the Bureau of Chemistry, were completed during the year. Field work was completed in the studies of California big trees and bristlecone fir, and of turpentine orcharding and laboratory work in a cooperative investigation of turpentine adulterants. A descriptive study of the forests of Suffolk and Nassau counties, Long Island, was begun and finished; investigations of Pacific coast tan-bark trees and of basket-willow culture were continued; and an investigation of

methods of turpentine distillation, with special reference to improving commercial processes of production in this country, was begun. Experiments bearing on the culture of the sugar maple were made to supplement a study of the sugar-maple industry previously completed. The collection of forest photographs received notable additions by exchange with foreign countries, and by gifts as well as by the normal increase from the new photographs obtained by the Bureau of Forestry in connection with its field work.

### FOREST EXTENSION.

In the work of cooperation with private owners to promote forest planting the Bureau of Forestry prepared during the year 42 planting plans for an aggregate of over 2,800 acres. Altogether 334 planting plans have been made for land in 52 States and Territories. This is a work of high utility, particularly in those regions of the West where timber and water are scarce and farm protection against hot or cold winds is important. Cooperation is confined to the giving of expert advice; all the expense of the planting is borne by the owner. By the adoption of a system of regional studies rapid progress is being made toward a point at which this expert advice can ordinarily be given by correspondence. When this point is reached, the Bureau of Forestry will be in a position to contribute materially to the well-being of wide regions at almost no expense.

In forest-reserve planting extensive operations are now under way in Nebraska, where previous experiments have pointed out how planting on a large scale can be made successful. In the spring of 1904 there were taken from the nursery and planted in the Dismal River Reserve 300,000 seedlings, of which over 90 per cent survived. Highly efficient and economical methods of doing this work were devised. Preliminary preparations for planting were made in the Niobrara Reserve, Nebraska, the San Gabriel Reserve, California, and the Pikes Peak Reserve, Colorado.

Studies of natural forest replacement were conducted in Colorado, western Kansas, western Nebraska, northern New Mexico, and New England.

The investigation of forest fires, with especial reference to methods of preventing and controlling them, has been continued, and encouraging progress made. The study of the reclamation of shifting sand through forest growth was continued.

### FOREST PRODUCTS.

The studies in timber preservation conducted by the Bureau of Forestry are yielding results of large economic importance. Extensive experiments were conducted during the year in the West with longleaf, shortleaf, loblolly, lodgepole, and western yellow pine, spruce, and white and red fir ties. Ties were employed for these tests partly because of the opportunities for experiments of general application afforded by the selection of this form of timber, and partly because of the intrinsic importance of the specific subject of tie preservation. These experiments have already developed a number of important facts connected with timber seasoning and preservation.

In the Central States similar experiments were made with a large number of hardwood timbers, especially with those possibly capable of

filling the place for certain uses of white oak and hickory, the supply of which is dwindling fast. It was found that chemical treatment will permit their use for structural purposes; that conspicuous improvement in present methods of seasoning is possible; and that the effectiveness of preservative treatment of red oak is greatly increased by thorough seasoning both before and after treatment.

In the East the seasoning of and application of preservatives to telegraph and telephone poles and cross arms were investigated, and discoveries which render possible considerable economies were made. Further experiments to reduce the rate of decay of poles at the butt are under way. Seasoning experiments are in progress with Adirondack hardwoods.

The investigation of the strength of timbers directly meets the needs of engineers, architects, and others who have to do with the use of construction timber, and is likely to be followed by a revision of specification requirements and grading rules. Large timbers in market forms and sizes, of red fir, western hemlock, and loblolly and longleaf pine were tested. Eastern investigations of many species are needed in the interest of the most economical use of our timber supply; for it is undoubtedly true that timber trees neglected hitherto will be found to possess unsuspected value.

Other important lines of investigation pursued were a study of the mechanical properties of red gum, which established, among other things, its suitability for carriage manufacture; studies of the relative strength of various forms of tie fastenings and of devices to prevent the rapid wear of soft timbers protected against decay by preservative treatment; and a study of the effect of moisture content on the strength of timber.

### LOUISIANA PURCHASE EXPOSITION FOREST EXHIBIT.

The most extensive and complete forest exhibit ever made by this Bureau was installed at the Exposition at St. Louis. It included the execution out of doors of tree-planting plans and the setting of trees adapted to every part of the country, and an exhibit of the best forest nursery methods. A full exhibit by transparencies, pictures, and apparatus illustrated every phase of our forestry work and forest conditions in all parts of the country. Methods of testing commercial timber were illustrated, and an experimental plant for wood preservation was established and operated during the Fair.

## BUREAU OF CHEMISTRY.

The Bureau of Chemistry, during the last few years, has expanded the sphere of its activity in many directions.

### AID TO OTHER DEPARTMENTS.

First to be noticed of this expansion is the work done under that authorization by Congress which secures the services of this Bureau for the other Departments of the Government. Under this authority the amount of work which has been done for the other Departments has rapidly increased. This is especially true of chemical determinations in collaboration with the Treasury Department.

For the Department of Justice extensive investigations have been undertaken to determine the injuries suffered by forest reserves from the fumes of smelters. For this Department, also, numerous chemical investigations have been made in connection with cases arising in the administration of justice in the Indian reservations and in certain cases of poisoning which have occurred within those reservations.

For the Post-Office Department extensive examinations have been made of canceling stamps and the inks used therewith; also of alleged remedies offered by advertisements through the mails and regarded by the postal authorities as fraudulent in their nature.

For the various Departments a large number of analyses have been made of articles offered under contract to determine whether these articles are of the quality and purity specified in the contracts.

### FOOD INSPECTION.

The second important item in the expansion of the work of the Bureau of Chemistry has been the establishment of inspection for imported food products. Attention is invited to the fact that under this law the character of food products imported to this country has been greatly improved.

In former years the United States was regarded as the dumping ground for the refuse teas of the commerce of the world. Many years ago, in order to overcome this evil, a system of inspection of imported teas was established and has since been maintained. Under the beneficent working of this system Americans are now certain of being able to purchase pure and wholesome tea, since it is almost impossible for spurious and adulterated teas to find their way into this country. Congress has now extended this system of inspection to all foods, beverages, and condiments imported into the United States. There is every reason to believe that when this system is thoroughly established an improved condition comparable to that which has taken place in teas may be anticipated.

### FOOD STANDARDS.

Another important advance which deserves special attention is that relating to standards of purity for food products. The Secretary of Agriculture has been authorized by Congress to fix standards, and in order that they may be just and reasonable he has been authorized to call to his assistance the experts of the Association of Official Agricultural Chemists and other experts, as he may see fit, to advise him in regard to such matters. The work of ascertaining these proper standards, in collaboration with the Association of Official Agricultural Chemists, has been committed to the Bureau of Chemistry. Already considerable progress has been made along this desirable line of investigation and a number of standards of food products have already been fixed by proclamation. It is proposed to extend this useful work until practically all the substances used by our citizens as foods, beverages, and condiments shall have a fixed standard of purity to which all manufacturers may attain by proper care in the preparation of products of this kind.

### EXPERIMENTS WITH BORAX IN FOOD.

The work of the Bureau of Chemistry in the study of the effect upon digestion and health exerted by preservatives, coloring matter, and other substances added to food has been continued in the same painstaking and thorough manner as in the preceding year. The great quantity of data secured in this work in relation to the effect of borax has been compiled and is now being published. These studies of the effect of borax have led to certain definite conclusions which are of the utmost interest to manufacturers of food products into which borax has often been introduced, and to the consuming public.

The effects of the preservatives upon the functions of the body have been studied in detail. It is admitted that there is a necessity for mineral substances in the blood, as they are essential to the functional activity of the various organs of the body, irrespective of any part they may take in direct nutrition. The necessity, for example, of saline solutions in the blood is known to every physiologist, but it is evident that these saline solutions can be derived from materials of common occurrence and naturally found in food products, or usually added thereto as condiments, such as common salt.

At the same time it must not be forgotten that this does not excuse the introduction of other soluble bodies which have a detrimental effect upon the functional activities, and the excretion of which imposes an additional burden upon the excretory organs. For although such substances might not impair the efficiency of these organs for a number of years, they would finally produce a condition of exhaustion which would be followed by serious consequences.

### USE OF SMALL QUANTITIES AS PRESERVATIVE.

The argument that small quantities of deleterious substances may be used without harm is not logical, nor can it be based upon the result of the experiments which have been made. On the other hand, the logical conclusion which seems to follow from the data at our disposal is that the use of boric acid and equivalent amounts of borax should be restricted to those cases where the necessity therefor is clearly manifest, and where it is demonstrable that other methods of food preservation are not applicable, and that without the use of such a preservative the deleterious effects produced by the foods themselves by reason of decomposition would be far greater than could possibly come from the use of the preservative in minimum quantities. In these cases it would also follow, apparently as a matter of public information, and especially for the protection of the young, sick, and debilitated, that each article of food should be plainly labeled and branded, so as to show the character and quantity of the preservative employed.

### EFFECT UPON HEALTH OF VARYING AMOUNTS OF BORAX.

The most interesting of the observations which were made during the progress of the experiments was in the study of the direct effect upon health of boric acid and borax when administered in food. When boric acid or its equivalent in borax is taken with the food in small quantities, not exceeding half a gram (7½ grains) a day, no notable effects are immediately produced. The medical symptoms of the cases

in long-continued exhibitions of small doses, or in large doses extending over a shorter period, show in many instances a manifest tendency to diminish the appetite and to produce a feeling of fullness and uneasiness in the stomach, which in some cases results in nausea, with a very general tendency to produce a sense of fullness in the head, which is often manifested as a dull and persistent headache. In addition to the uneasiness produced in the region of the stomach, there appear in some instances sharp and well-located pains which, however, are not persistent. Although the depression in the weight of the body and some of the other symptoms produced persist in the after periods, there is a uniform tendency manifested after the withdrawal of the preservative toward a recovery from the unpleasant sensations in the stomach and head above mentioned.

The administration of boric acid to the amount of 4 or 5 grams per day, or borax equivalent thereto, continued for some time, results in most cases in loss of appetite and inability to perform work of any kind. In many cases the person becomes ill and unfit for duty. The administration of 3 grams per day produced in many cases the same symptoms, although it appeared that a majority of the men under observation were able to take 3 grams a day for a somewhat protracted period and still perform their duties. They commonly felt injurious effects from the dose, however, and it is certain that the normal man could not long continue to receive 3 grams per day.

In many cases the same results, though less marked, follow the administration of borax to the extent of 2 grams and even of 1 gram per day, although in some of the cases studied the illness following the administration of borax and boric acid in those proportions may be explained by other causes, chiefly la grippe.

The administration of borax and boric acid to the extent of one-half gram per day yielded results markedly different from those obtained with larger quantities of the preservatives. This experiment, conducted as it was for a period of fifty days, was a rather severe test, and it appeared that in some instances a somewhat unfavorable result attended its use. On the whole the results show that one-half gram per day is too much for the normal man to receive regularly. On the other hand, it is evident that the normal man can receive one-half gram per day of boric acid, or of borax expressed in terms of borac acid, for a limited period of time without much danger of impairment of health.

It is, of course, not to be denied that both borax and boric acid are recognized as valuable remedies in medicine. There are certain diseases in which these remedies are regularly prescribed, both for internal and external use. The value which they possess in these cases does not seem to have any relation to their use in the healthy organism except when properly prescribed as prophylactics. The fact that any remedy is useful in disease does not appear to logically warrant its use at any other time.

It appears, therefore, that both boric acid and borax, when continuously administered in small doses for a long period or when given in large quantities for a short period, create disturbances of appetite, of digestion, and of health.

### TESTING OF ROAD MATERIALS.

The work of the Road Material Laboratory, now the Division of Tests, has been much broadened and its value and importance increased during the past fiscal year. The routine tests on road materials are carried on as usual, and several of the tests have been improved and standardized. The importance of testing rocks to be used in road building is being recognized at the present time by the leading highway engineers of the country, and a number of laboratories modeled after the Department Road Material Laboratory have been established in different places.

### STUDY OF CLAYS FOR ROAD MAKING.

Of the 228 samples of road materials reported for the past year, 35 were clays. This is mentioned to show the high percentage which clay bears to the whole number of samples received; for it is a fact not generally recognized that in vast areas throughout the country clay is the only material of which roads can be built. For this reason much time has been spent in studying the physical properties of clays in the endeavor to devise methods by which they can be utilized in road making. It may be mentioned here that up to the present time but one method of using clay in road building has been known—that is, to mix it in the proper proportion with sand. This method, however, is not always practicable, for in many districts sand is difficult to obtain. Many of the Western railroads running through areas of the country where rock ballast was impossible to obtain have been in the habit of burning or clinkering clay with open wood and coal-slack fires along the line of their roads. This clinkered clay has been successfully used for some time past as a railroad ballast.

Many inquiries had been received as to methods of treating roads in some of the Western and Southwestern States, where, owing to absolute lack of hard materials and to the extremely sticky nature of the country clays, many of the farmers were absolutely cut off from the towns during the wet portions of the year. It was apparent that if the local clays could be cheaply burnt to a hard, dense clinker a good road material could be provided. Preliminary to actual work on a large scale and expensive experiments on the ground, it was necessary to make laboratory tests of the clays to see whether they would burn to a dense, hard clinker. Samples of the well-known so-called gumbo clay were sent to the laboratory from the Yazoo district of Mississippi. These samples were experimentally burned in the laboratory of the Division, and it seemed quite possible to use the clays in the manner as indicated above.

Following upon this experiment, the Office of Public Road Inquiries built an experimental road in Yazoo City which has been reported successful. It is needless to point out the great importance of the success of such experiments in relation to road building in localities in which no rock is to be had.

### IMPORT AND DOMESTIC PRODUCTION OF CLAYS.

Since it is shown by many letters of inquiry that information is being sought by people all over the country on the subject of testing

of clays for the various purposes for which they are used, other than road building, special tests are now carried on to that end. A furnace has been installed and actual burning tests on clays are now made. In order to further stimulate interest in the development of native clay bodies, a special circular was issued on "The useful properties of clays." The aim of this circular was to give information in the simplest possible way to people who were not supposed to possess technical knowledge of clays. That the object has been attained is shown by the increased correspondence of the Division on this subject. The circular particularly points out that for the year 1902, the last year for which the official figures are available, the total imports of foreign clays to this country were valued at $1,154,805, while the domestic clays produced were valued at $2,061,072. Since the country possesses unusually fine clay bodies, a great many of which up to the present time await development, any stimulation of interest among the people to develop our native clays must be of great value.

### CEMENTING POWER OF ROAD MATERIAL.

The satisfactory investigation of the important property of binding or cementing of road materials when used upon roads has been continued and much new evidence has been obtained.

Under the old rule-of-thumb methods of road building one sort of rock was supposed to be as good as another. Miles and miles of expensive roads have been built in a haphazard way, of any sort of material that was available, and many of such roads have "raveled" and gone to pieces almost as rapidly as they could be built. Since the establishment of the proper methods of testing and investigating these materials, there has been noticed a great improvement of roads. The most intelligent and progressive of the State highway engineers are availing themselves of the opportunities extended to them by the Department of Agriculture for studying and familiarizing themselves with the physical properties of the materials which they are about to use before risking the public moneys in expensive work.

The hardness and toughness of a rock which is going to be used on a road are, as everyone knows, important properties, but the property which causes this rock under the influence of traffic to bind or cement together so as to form a smooth, even, impervious shell on the surface of a road is even more important. When the work of the Road Material Laboratory first began the importance of this quality had hardly been recognized, and absolutely nothing was known as to the reason why one rock should possess this property to a very high degree and another of perhaps identically the same name and species should be entirely lacking in it. The closest investigation has been given to this subject and to the collection of all possible data and information, not only from the theoretical and laboratory standpoint, but also from a practical point of view. It is safe to say that its satisfactory solution has been accomplished. A bulletin on "The Cementing Value of Road Materials" has just been published, and the publication of more work in the same line will follow shortly.

A new test for determining the toughness of rock and asphalt mixtures for road building was brought out during the past year, and several new tests are at present being developed.

### CONCRETE FOR FENCE POSTS, ROOFS, ETC.

On the 1st of last July the Road Material Laboratory was made a Division, and its name changed to the Division of Tests. The object of this change was to establish in the Department a laboratory where all materials of construction relating to agriculture could be tested and allied problems investigated. In pursuance of this change, several lines of research have been taken up. The first problem selected was to determine whether or not a thoroughly practical concrete fence post reenforced with steel could be made sufficiently cheap to be used by farmers. The advantages of such fence posts would be many. The price of wood, particularly of the varieties used for fence posts, is continually rising, and even now the price is almost prohibitory in some sections of the country. Further, a properly constructed concrete fence post would be permanent, as it would neither rot nor undergo disintegration. A variety of methods of reenforcement have already been tried, and the experiments are being pushed as rapidly as possible. The results so far obtained have been most satisfactory.

Experiments of a similar nature to the above are about to be begun on methods for making concrete drains, watering troughs, roofs, and barns, with the hope that concrete construction, so rapidly developing in the large cities, can be applied with benefit to the farm.

The question of the structure and constitution of hydraulic cements is a matter of the very greatest importance. The Division of Tests has in preparation a paper which I have good reason to believe will be accepted as the solution of this much-discussed question.

### USE OF OIL ON ROADS.

Much interest has been felt in different parts of the country in the use of oil for treating the surfaces of highways, in order to lay the dust and to offer a hard, impervious, waterproof surface. It is well known that in California such treatment of roads has met with a high degree of success. Similar experiments, however, when carried out in the East, proved complete failures; the Eastern oil failed to bind on the surface of the road, and did not lead to the desired result. When it was found that the main difference between the California natural oils and the Eastern and Texas oils lay in the fact that the California oils contained an asphalt base, while the Eastern oils contained a petroleum or vaseline base, the Division of Tests immediately suggested that the cause of the failure of previous Eastern experiments was directly due to this fact, and road builders throughout the country were urged to make experiments with mixtures of crude oils with crude asphaltum. Last summer the Commissioners of the District of Columbia consented to make such an experiment. A street in Washington was selected for the purpose and a number of mixtures of Southern crude oil and asphaltum were spread in adjacent sections. At first the experiment was looked upon as a failure, but the road has been steadily improving, and at present there is every promise of the experiment proving a success. If it proves true that mixtures of Eastern crude oil and asphaltum make as good roads as the California oils do, a very great advance will be made toward the betterment of our rural highways.

### SCHOOL FOR ROAD BUILDING.

One of the chief lines of work for this division during the present year is the establishment of a school of road building. The object of

this school is to give a one-year course in highway engineering and the testing of road materials to about four young men who have received degrees from reputable engineering schools. These students are to be selected by a civil-service examination. They will devote six months to the study of road-building problems and road materials and six months to field work, which will consist of actual road construction. Men with such training are sure to be of the greatest service to the country, not only in constructing highways, but in disseminating accurate knowledge on highway construction.

## BUREAU OF SOILS.

The study of soils and their management with regard to their values for producing crops has been continued. The composition of soils varies greatly in different localities and in quite limited areas. Our soils were nearly all fertile originally, but continued cultivation has in many cases reduced their powers to grow crops as they did when first brought under the plow. The best methods of restoring soils that have been cultivated too long is a pressing question not only in the older settled States, but is insistent in most of the newer lands of the West where wheat has been grown until profitable crops of it are no longer to be had.

Rotation of crops and laying down in pastures to be grazed until the soil fills with roots is the well-known restorative, but soils vary greatly in our several States and are adapted to the growth of special crops in our several latitudes, so that a general knowledge of their composition is of prime importance before the tiller can put them to their most profitable uses. Droughts limit the yield on soils that have lost their organic matter through continued cultivation without an adequate return of fertilizers in the shape of decaying vegetation. Commercial manures will not adequately remedy the evil, as they do not return to the soil what enables it to retain moisture. Soils vary so much in this regard, from coarse sand to retentive clay, that each requires careful study to enable the farmer to manage it to the greatest advantage.

The Bureau of Soils is mapping our various areas to the end that the residents on each may as soon as possible learn the peculiarities with which they have to deal. This work is comparatively new. Its value has been overlooked by the educator. A force of soil experts is being trained in the Department to help the cultivator to a better knowledge of the possibilities of his acres throughout our broad land, in order that run-down lands may be reclaimed and that the fertility of our newer lands may be maintained to meet the requirements of a rapidly increasing population.

We are bringing plants from all foreign countries to diversify our industries and enable our husbandmen to grow what has been and still is costing us large amounts of money. A knowledge of the character of the soils from which they come and on which they have been developed is imperative, and suggests to us the wisdom of becoming familiar with the soils as well as the climates to which we introduce them, if we are to maintain them here in their excellence or improve them, giving them better conditions than they had in the countries where we found them. Within the limits of our climates and soils we hope to improve everything we import through a superior aggrega-

tion of scientists who are making research into all the conditions of plant life, the soil being of greatest importance.

## PROGRESS OF THE SOIL SURVEY.

The area surveyed and mapped during the fiscal year was 29,058 square miles, or 18,597,120 acres. The area surveyed during the preceding fiscal year was 23,293 square miles, which, together with the work done prior to that time, makes a total area surveyed up to that date of 74,795 square miles, or 47,868,800 acres.

The work was carried on during the past year in 68 areas in 33 States. On an average 20 parties have been working continuously throughout the year, in the Southern States during the fall and winter and in the Northern States during the spring and summer months.

The areas surveyed and the cost of the work in each area are shown in the following table:

*Areas surveyed and mapped during fiscal year ended June 30, 1904, and the areas previously reported.*

| State or Territory. | Work during 1904. | Work previously reported. | Total area surveyed. | |
|---|---|---|---|---|
| | *Sq. miles.* | *Sq. miles.* | *Sq. miles.* | *Acres.* |
| Alabama | 2,396 | 1,223 | 3,619 | 2,316,160 |
| Arizona | ..... | 611 | 611 | 391,040 |
| Arkansas | 626 | 251 | 877 | 561,280 |
| California | 1,679 | 3,921 | 5,600 | 3,584,000 |
| Colorado | 228 | 1,345 | 1,573 | 1,006,720 |
| Connecticut | ..... | 518 | 518 | 331,520 |
| Delaware | 314 | ..... | 314 | 200,960 |
| Florida | 485 | 548 | 1,033 | 661,120 |
| Georgia | 853 | 757 | 1,610 | 1,030,400 |
| Idaho | 58 | 1,077 | 1,135 | 726,400 |
| Illinois | 2,333 | 3,592 | 5,925 | 3,792,000 |
| Indiana | 889 | 387 | 1,276 | 816,640 |
| Iowa | 1,287 | 1,016 | 2,303 | 1,473,920 |
| Kansas | 999 | 464 | 1,463 | 936,320 |
| Kentucky | ..... | 837 | 837 | 535,680 |
| Louisiana | 1,446 | 942 | 2,388 | 1,528,320 |
| Maryland | 29 | 2,684 | 2,663 | 1,704,320 |
| Massachusetts | 386 | 410 | 796 | 509,440 |
| Michigan | 517 | 858 | 1,375 | 880,000 |
| Minnesota | ..... | 233 | 233 | 149,120 |
| Mississippi | 1,352 | 1,317 | 2,669 | 1,708,160 |
| Missouri | 1,111 | 919 | 2,030 | 1,299,200 |
| Montana | ..... | 107 | 107 | 68,480 |
| Nebraska | 1,195 | ..... | 1,195 | 764,800 |
| New Jersey | ..... | 1,303 | 1,303 | 833,920 |
| New Mexico | ..... | 129 | 129 | 82,560 |
| New York | 986 | 1,558 | 2,544 | 1,628,160 |
| North Carolina | 687 | 4,646 | 5,333 | 3,413,120 |
| North Dakota | 386 | 856 | 1,242 | 794,880 |
| Ohio | 1,400 | 1,355 | 2,755 | 1,763,200 |
| Oregon | 60 | 386 | 446 | 285,440 |
| Pennsylvania | ..... | 1,204 | 1,204 | 770,560 |
| Porto Rico | ..... | 330 | 330 | 211,200 |
| Rhode Island | 500 | ..... | 500 | 320,000 |
| South Carolina | 1,159 | 2,032 | 3,191 | 2,042,240 |

*Areas surveyed and mapped during fiscal year ended June 30, 1904, and the areas previously reported*—Continued.

| State or Territory. | Work during 1904. | Work previously reported. | Total area surveyed. | |
|---|---|---|---|---|
| | *Sq. miles.* | *Sq. miles.* | *Sq. miles.* | *Acres.* |
| South Dakota | ..... | 485 | 485 | 310,400 |
| Tennessee | 1,596 | 547 | 2,143 | 1,371,520 |
| Texas | 2,564 | 1,733 | 4,297 | 2,750,080 |
| Utah | 806 | 994 | 1,800 | 832,000 |
| Vermont | 227 | ..... | 227 | 145,280 |
| Virginia | 656 | 2,747 | 3,403 | 2,177,920 |
| Washington | ..... | 510 | 510 | 326,400 |
| West Virginia | 39 | ..... | 39 | 24,960 |
| Wisconsin | ..... | 955 | 955 | 611,200 |
| Wyoming | 309 | ..... | 309 | 197,760 |
| Total | 29,058 | 45,737 | 74,795 | 47,868,800 |

RECAPITULATION.

| | |
|---|---|
| Cost of field work | $64,238.36 |
| Supplies | 1,464.18 |
| Traveling expenses between areas | 4,115.56 |
| Other expenses | 2,783.32 |
| Total cost of soil survey | 72,601.41 |
| Paid by State organizations | 2,377.57 |
| Paid by Department of Agriculture | 70,223.84 |
| Area surveyed ..... square miles.. | 29,056 |
| Cost of work in field per square mile | $2.21 |
| Transportation, supplies, and other expenses, per square mile | .29 |
| Average total cost per square mile | 2.50 |
| Average cost to Department of Agriculture per square mile | 2.42 |

The cost of the work in the field has increased from $2.19 per square mile, reported last year, to $2.21 per square mile during the year just closed; while the average cost of the work to the Department of Agriculture, including all transportation, supplies, and office expenses, has decreased from $2.63 per square mile, reported last year, to $2.42 per square mile during the year just ended.

There has been a continued demand for this soil-survey work, and there are on file demands for about two years' work yet unfilled, while requests continue to come in which can not be immediately considered.

There has been a steady demand from colleges, experiment stations, and private enterprises for men trained in this soil-survey work, and during the past year several men have left this Bureau to accept more lucrative positions elsewhere.

## PUBLICATION OF THE REPORTS AND MAPS.

At the last session of Congress provision was made to print in the form of "advance sheets" the several reports as they are prepared—500 copies for the use of each Senator from the State, 2,000 copies for the use of each Representative of the Congressional district or districts in which the survey is made, and 1,000 copies for the use of the Department of Agriculture. Although this act was passed too late to materially influence the printing of the report of the work for the field season of 1903, it will very greatly facilitate the distribution of the report and is proving a very advantageous way for the printing and distribu-

tion of the report of the work for the field season of 1904, the manuscript of the first reports of which have already gone to the Public Printer.

## ALKALI-LAND RECLAMATION.

In my last report attention was directed to the important results obtained in the reclamation of alkali soils by underdrainage and surface flooding. This work was undertaken as an object lesson to farmers in those irrigated districts of the West where any considerable trouble had been experienced with the rise of alkali and the consequent depreciation in the value of the land. The results of the past year have again proved the wisdom of inaugurating these demonstration experiments in alkali reclamation. Great interest in the work has been aroused on every side, and frequent inquiries have been received from farmers owning alkali land asking instructions as to the best methods to prevent the further deterioration of their lands and advice as to the reclamation of tracts now partly or wholly unproductive.

On the reclamation tracts established during 1902–3 much progress has been made during the past year, and indications point to the complete reclamation of the lands under experimentation at an early date. On the 40-acre Swan tract, near Salt Lake City, the results have been especially gratifying. At the inception of the work there, in September, 1902, a detailed soil survey showed the first 4 feet of soil over the 40 acres to contain more than 6,650 tons of soluble salts (alkali). In May, 1903, there had been removed in the drainage water, by actual measurement, nearly 50 per cent of this immense total, and in the October following the proportion removed had reached 82 per cent, thus leaving only 1,221 tons of the original 6,650 tons still in the 4-foot section of the entire tract. The greater part of the salt originally in the surface foot had been removed, while even the fourth foot had lost 69 per cent of the alkali originally present.

In the spring of 1904 this tract was sowed to oats, barley, and wheat, as it was believed to be sufficiently sweetened for shallow-rooted crops. The land was not in the best condition for seeding. Nevertheless, on many of the checks 90 per cent of a stand was secured, and on all checks but little evidence of alkali was observed. The flooding process was resumed on those checks having the poorest crop prospects, and will be continued on all the tract after harvest, and by next spring it is expected that reclamation will have progressed to such an extent that the deep-rooted alfalfa can be grown, when the land will be returned to the owner. The growing of the crops of the present year and the seeding of the land to alfalfa are under the control of the Utah experiment station in cooperation with the Department.

The progress of a similar work on a 20-acre tract at Fresno, Cal., has been no less gratifying than that at Salt Lake City. The problem here as regards the drainage was more difficult, as the water had to be removed by pumping, while the soil was fine and silty and clogged the drain pipes. These difficulties have been surmounted, however, and within a year it has been possible to grow crops of alfalfa and wheat on a considerable part of the 20 acres under experiment. The Fresno work I deem particularly important, as it is situated in a wealthy district, where large areas of once productive land have been abandoned because of the rise of alkali and the swamping of areas by

seepage water from the excessive irrigation of higher lying lands and from the canals.

In the Gervais tract, situated 3 miles from North Yakima, Wash., it is estimated that flooding from July to November, 1903, washed approximately 70 per cent of the total salts out of the soil to a depth of 4 feet. Here, as in the Fresno area, much valuable land has been ruined by seepage water and the rise of black alkali. Flooding of this tract was resumed in 1904, and it is expected that reclamation will have progressed to such an extent that crops can be grown in the coming season.

A more recent experiment has been instituted at Tempe, Ariz., where the installation of the drains was completed in February, 1904. An unprecedentedly dry season and a consequent lack of water have prevented much progress in the work at this point.

Another tract has been taken up for reclamation work near Billings, Mont. This tract is situated in the Yellowstone River Valley, where great progress has been made in growing alfalfa as a winter feed for the cattle and sheep that pasture on the adjoining mountain ranges during the summer. Shortly after irrigation began in this district alkali began to appear and the ground water rose rapidly, waterlogging wide areas of the land to such an extent that its cultivation had to be discontinued. An examination of certain parts of the valley, made by the Bureau of Soils in 1897 and 1898, showed the extent of the damage, and when, in 1902, a detailed soil survey was made around Billings it was found the trouble had greatly increased and intensified. Even in the two years that have elapsed since the survey was made, many fine alfalfa fields have been abandoned and now are heavily incrusted alkali flats. The farmers here are fully alive to the seriousness of the situation, but seem unable to cope with the problem.

Many tracts of land were offered the Department for the purpose of experiment, and a number of farmers have indicated their intention to undertake similar work themselves, showing the interest taken in the work. This, however, has not proceeded far enough to permit a full report at this time. I have, however, the fullest confidence in the final success of the undertaking, as well as a firm belief that it will lead to individual or concerted action on the part of those of our citizens most interested, with the result that both the agricultural and stock-raising interests of this part of the country will be greatly benefited.

It seems, then, that within three years, at most, practically worthless land, so heavily charged with injurious salts as to be unfit for any form of agriculture, may be reclaimed to grow any ordinary field crop; that the method of doing this is simple; and that the expense involved is such that the work may in many instances be economically undertaken by individual, corporate, or State initiative. Taking the Utah tract for example, the land reclaimed has increased from a purely nominal value to an actual value, judged by the value of surrounding unaffected lands, of $250 to $300 an acre. The total expense of reclamation, taking everything into consideration, is but a small fraction of this enhanced value.

### TOBACCO INVESTIGATIONS.

In the line of tobacco investigations carried on by the Bureau of Soils the most important work during the past fiscal year has been the

experimental growing of Cuban seed tobacco on certain soils in Texas, Alabama, and South Carolina. This work was begun in July, 1903, in cooperation with leading farmers in the several States. Thirteen acres were planted in Texas, 3 in Alabama, and 3 in South Carolina. The success of this first trial led to further plantings by the Department in 1904, when trial tracts were established at Nacogdoches, Crockett, and Giddings, in Texas, a total of 12 acres being planted. One tract in Perry County, Ala., and one in Orange County, S. C., were established, each with 3 acres in tobacco. Samples of the tobaccos grown in 1903 were submitted to the trade, and the opinion is that the Texas leaf has considerable merit, both in regard to flavor and aroma, and some have pronounced it to be superior to any filler yet grown in this country. The Alabama filler leaf is considered fair, but not equal to the Texas leaf, while the filler grown in South Carolina does not meet with as much favor as that grown in the two States already mentioned.

The commercial value placed upon this leaf by different tobacco brokers varies considerably, ranging from 18 to 40 cents a pound.

Some bales of Texas leaf have been disposed of at the higher figure. Final judgment of the success of this venture must be postponed until further advices are received from the dealers and manufacturers to whom working samples have been submitted.

### GROWING AND CURING CIGAR TOBACCOS IN OHIO.

Experiments in growing the Cuban type of filler have also been carried on on a 10-acre tract in Ohio. Owing to the heavy nature of the leaf it is impossible to judge of its aroma at present. The tobacco of this type raised in the preceding year is only just ready for the manufacturer. The aroma has been pronounced good, but it is believed that the leaf is too heavy for the taste of the general public and the aim this year is to try to produce a somewhat lighter leaf. The results of these experiments in growing Cuban filler leaf seem to warrant a continuation of the experiments in the Southern States and possibly in Ohio for the succeeding year upon somewhat broader lines; and it is hoped that through the efforts of the Bureau of Soils an extension of the domestic filler leaf interests may be accomplished.

By far the most important work in Ohio, however, has been the further introduction of the bulk method of fermenting cigar tobaccos. This work was begun in 1902, when 655,200 pounds were fermented. In 1903, 4,204,800 pounds were fermented, and in 1904 the quantity was increased to 10,208,000 pounds, distributed among the several types of tobacco as follows: Zimmer Spanish, 5,850,000 pounds; Little Dutch, 582,000 pounds, and seed leaf, 3,776,000 pounds. As the work of the Department there is simply supervisory, and entails the cooperation of the warehousemen, this great increase evidences the remarkable interest that this change in the methods of handling tobacco has to the grower and the tobacco dealer. Its use not only avoids great loss formerly suffered from fungous growth in the case-fermented tobaccos, but also tends to improve the grades of tobacco and therefore increase the profits both to the grower and the handler.

### WRAPPER LEAF IN CONNECTICUT.

The experiments in the production of a wrapper leaf in the Connecticut Valley have been continued during the last year. In the begin-

ning of these experiments in 1900, work was undertaken in cooperation with the Connecticut experiment station at Poquonock, on one-third of an acre of land. The tobacco grown on this small plot was submitted to leading leaf dealers and brokers in New York for their opinion. On their judgment, which was very favorable, the Department felt justified in conducting further work in Connecticut upon a considerably larger scale. In 1901, therefore, 40 acres were planted, this time in cooperation with leading tobacco growers in the valley. This tobacco was of satisfactory quality and was sold at Hartford, and although it had been grown under very unsatisfactory climatic conditions a very good price was obtained at the sale. In 1902 a larger acreage was planted by the Connecticut farmers; and leaf dealers of New York—men who had spent their lives in the tobacco trade and who were everywhere recognized as good judges of tobacco—invested money in the production of shade-grown tobacco, not upon the reports of the Bureau of Soils, but on their own judgment of the satisfactory character of the leaf.

Owing to unfavorable climatic and adverse trade conditions, which were entirely beyond the control of the grower, the tobacco produced during that season failed, to a certain extent, to meet the demands of the manufacturers. The climatic conditions in 1903 were very similar to those in 1902—that is, they were unfavorable to the production of a wrapper leaf of the very best grade, and there was not so large a demand for this tobacco as was expected. In 1903 the Bureau had practically ceased its work in Connecticut; but in 1904, still having confidence in the opinion of the trade, and believing that the method of growing tobacco for wrappers under shade is correct, it has conducted an experiment at Tariffville, Conn., where a crop has been produced on a 4-acre plat. Owing to the recent tendency on the part of the trade to wrap the better grades of cigars with the Cuban rather than with the Sumatra style of leaf, 1 acre of this plat was planted to Cuban seed tobacco.

Tobacco of this type grown under shade in Connecticut was exhibited by the Department at the Louisiana Purchase Exposition at St. Louis, and to it was awarded the grand prize as being a leaf of the highest standard of excellence for cigar wrappers.

In connection with this matter of the producing of shade-grown wrapper in Connecticut, the Bureau of Soils has been making an investigation as to the demands of the market for the Cuban type of leaf and as to the practicability of building up a demand for Connecticut shade-grown tobacco of this type. Recent sales of this tobacco have been made, principally in New York and Philadelphia, and the following table shows the distribution of nearly 300 bales of such tobacco and the average price per pound of the lots as sold:

*Prices received for Connecticut shade-grown tobacco.*

| | | |
|---|---|---|
| For domestic use, 134 bales: | | |
| Bales, 17 | per pound.. | $1.75 |
| 1 | do.... | 1.65 |
| 24 | do.... | 1.50 |
| 3 | do.... | 1.45 |
| 3 | do.... | 1.40 |
| 4 | do.... | 1.35 |
| 60 | do.... | 1.25 |
| 1 | do.... | 1.00 |
| 1 | do.... | .75 |
| For domestic use, 134 bales—Continued. | | |
| Bales, 16 | per pound.. | $0.62½ |
| 4 | do.... | .35 |
| For export, 144 bales: | | |
| Bales, 14 | do.... | .70 |
| 30 | do.... | .32½ |
| 100 | do.... | .30 |
| Tops, 104 bales: | | |
| Bales, 90 | do.... | .10 |
| 14 | do.... | .08 |

This table shows that 134 bales have been sold for domestic use at an average price of $1.26\frac{8}{10}$ per pound, the highest price being $1.75 per pound for light wrappers, and the lowest price 35 cents per pound for short-sized second-quality leaf. The 144 bales sold for export, at an average price of $0.34\frac{4}{10}$, consisted of tobacco of a quality not suited to the home market, principally of sand leaves and short-sized, flimsy tobacco. Nearly all of this tobacco was shipped to the German market. The 104 bales, sold at an average price of $0.09\frac{7}{10}$, consisted of short top leaves, the tobacco having no wrapper quality, and being useful only as an inferior filler.

The tobacco experts of the Bureau of Soils see no reason to change their belief that the method of growing tobacco under shade in the Connecticut Valley will produce a wrapper leaf of great excellence, which can be economically used by the trade, and it would seem that the industry should be established upon a commercial scale.

### IMPROVING EXPORT TOBACCOS.

Up to the beginning of last year the tobacco work of the Bureau of Soils has been along the lines of improving the methods of culture and handling of the cigar tobaccos, but this year considerable demand has been made upon the Bureau to assist the growers of the heavy export types of tobacco. The low percentage of tobacco suitable for plug wrappers, and the poor price obtained by the majority of growers, have led the Bureau to make investigations into the production of this type of tobacco, the object being to see if both the yield per acre and the percentage of the higher grades could be increased. A 5-acre experimental plot in Appomattox County, Va., was selected for studying the problem. In this section the finest plug wrappers are grown, and the work would also be carried on close to the Richmond and Lynchburg markets. It is the plan of these experiments to grow the tobacco with different fertilizers and under different methods of culture, to see which will give the best financial results to the grower. It is the intention of the Bureau to extend this work in the future to other districts producing the shipping types of tobacco. It is yet too early to give the results of the present season's work.

## BUREAU OF ENTOMOLOGY.

Insect pests cause a loss to the staple crops of the United States estimated at some $500,000,000 annually. The main object of the Bureau of Entomology is to make thorough studies of the insects responsible for these losses and to apply the information gained to limiting or preventing them. The Mexican cotton boll weevil represents the most important field of work of this Bureau during the last few years, but the insect enemies of the cereals, fruits, and other staple productions have been the subject of careful study and experimental work. The results of this work have been notably successful, particularly in the case of the boll weevil and the bollworm.

### THE MEXICAN COTTON BOLL WEEVIL.

Congress originally provided $30,000 for the continuation of the investigation of the boll weevil and the bollworm for the fiscal year.

DEMONSTRATION FARMS.

Under this appropriation seven experimental farms were organized in Texas, located at Victoria, Wharton, Austin, San Antonio, Calvert, Willspoint, and Hetty, all together aggregating 558 acres of cotton. The seven localities represented typical variations in soil and climatic conditions of Texas, and enabled the Department to test various methods of controlling the boll weevil under different conditions. They included bottom lands, dry upland subject to irrigation, the black prairie land of Austin, and the soils of river valleys where the presence of timber and moist climate and almost exclusive production of cotton renders the weevil problem more serious than elsewhere. Other farms were on the high, rolling prairie land and river bottoms of the northern part of the State.

The minute investigation of the life history of the weevil, upon the knowledge of which any system of control of the pest and any modification of the present cultural system must naturally be based, was continued at the laboratory at Victoria. In the experimental fields attached to this laboratory also were tested poisons and machines. An expert assistant carried on a study of the weevil in Cuba, one of its native regions, with the hope of finding some effective parasite or some variety of cotton especially resistant to its attacks.

The exact spread of the boll weevil into new cotton regions was determined, and a special investigation of the usefulness of birds in controlling the weevil was instituted. The result of the work of the season of 1903 is summarized in three important publications issued by the Bureau.

Under the provisions of the special appropriation of $250,000 made available January 15, 1904, it was possible to greatly enlarge the work.

The number of experimental or demonstration farms was increased to thirteen for the season of 1904, aggregating 1,077 acres. During the previous season in not one of the seven experimental farms then under operation did the crop fall appreciably below the average production in the United States before the weevil came into Texas, namely, about half a bale to the acre. The cultural system which these farms were designed to illustrate has so far proved to be the only practicable means of controlling the boll weevil, and the work of past years has demonstrated its general success and feasibility. It is the outgrowth of several years of field experiments conducted by the Bureau of Entomology in Texas. The cotton on these farms is planted under a contract which gives the Department complete control of the culture of the crop.

SCIENTIFIC AND LABORATORY WORK.

In addition to the conduct of these demonstration farms, the more purely scientific and laboratory work relating to the study of details of the life history of the weevil and of the possibility of artificial propagation of parasites has been increased. Special work has been done in the attempt to eradicate isolated colonies, to control the danger of dissemination of the weevil by the gins and gin products, notably cotton seed, and the perfecting of quarantine plans to check or prevent the spread of the weevil from Texas to other cotton-growing States.

COOPERATION WITH THE LOUISIANA BOLL WEEVIL COMMISSION.

The weevil having already crossed the line into Louisiana, the Bureau of Entomology has been doing cooperative work with the Louisiana boll weevil commission in eradicating colonies in Louisiana and preventing its further spread into that State, with the idea of protecting not only Louisiana but the more eastern cotton regions. The work of this year has been most successful so far as the experimental farms and other work in Texas are concerned. It has proved impossible to exterminate the weevil in Louisiana, its distribution in the western counties of that State having become already too wide. Nevertheless its spread has been very greatly checked, and by proper quarantine and exterminative work its eastern progress can be very much delayed.

COLONIZATION OF THE GUATEMALAN ANT.

The Guatemalan ant, which was discovered by Mr. O. F. Cook, botanist in charge of investigations in tropical agriculture of the Bureau of Plant Industry, and which seems to be a very efficient enemy of the cotton-boll weevil in Guatemala, has been the subject of careful experimental work, begun under the Bureau of Plant Industry and afterwards transferred to this office, but remaining under the charge of Mr. Cook. This ant, determined by experts of the Bureau of Entomology as *Ectatomma tuberculatum*, is a tropical species of rather wide distribution throughout Central America and northern South America. Its specific habits were unknown prior to its discovery in Guatemala, but in this region, according to Mr. Cook, it seems to be an important natural enemy of the boll weevil. Nearly a hundred colonies of this ant, representing some 4,000 individuals, were conveyed to Texas, and have during the summer been placed at different points, and are being made the subject of careful study to determine whether this ant offers any hope of control to any extent of the boll weevil under the climatic conditions of Texas. The practical results of this importation can not now be foretold. The ant has, however, maintained itself during the summer, which is a feature of distinct encouragement.

THE BOLL WEEVIL STILL A MENACE.

The future work against the boll weevil in Texas and other Southern States will depend upon the action of Congress. The National menace still exists. The cotton planters of Texas have not all become convinced of the benefit to be derived by following the advice which the Bureau is enabled already to give, based upon its investigations of the past ten years, and therefore further investigation and further demonstration work seem to be necessary. Moreover, the imminent danger of the spread of the weevil to other cotton States indicates the necessity that the General Government should keep a force of men in the field to prove to the entire satisfaction of the planters the value of its advice, to continue the study of the insect in its rapidly changing environment, and to assist in quarantine measures and such other means as are necessary to restrict the spread of the pest.

### THE COTTON BOLLWORM.

The work on this insect, which is the second worst pest of the cotton and ranges throughout the cotton belt, has been continued during the last two seasons. The work during the season of 1904 has been much increased as a result of the special appropriation made available in January of this year. The principal lines of investigation followed out are field experiments in methods of control, and laboratory and field investigations of life history, habits, and parasitic and predaceous enemies of the insect. The field experiments have demonstrated that the cultural system of control recommended for the boll weevil furnishes the very best means also against the bollworm. The value of spraying and dusting with arsenical poisons and of trap crops was made the subject of careful experiments. This work was done on six contract farms over which the Department had absolute control, as in the case of the boll weevil, representing different localities and climatic and soil conditions. Cooperative work was also done at a number of other points, giving a total of some 400 acres on which experimental and demonstration work was carried on. The work outlined above has been most successful, and the Department is now able to recommend measures which will reduce damage from the bollworm to an inconsiderable amount.

In addition to these two principal cotton pests, other insects depredating on cotton, but of minor importance in comparison with these two, have been the subject of study.

### IMPORTED BENEFICIAL INSECTS.

The possibility of keeping injurious insects in check by the introduction and encouragement of natural insect enemies of such injurious species is a very popular subject with fruit growers and farmers, and notable successes have been achieved in this direction. The work in which the Department of Agriculture has been especially interested in this direction during the year has been a continuation of the effort to establish the Asiatic ladybird enemy of the San Jose scale in the Eastern States and the South African black scale parasite in California, together with the kelep or Guatemalan ant enemy of the cotton boll weevil, referred to elsewhere.

The Asiatic ladybird enemy of the San Jose scale (*Chilocorus similis*) maintained itself in numerous colonies in the South during the winter. An examination in Georgia in May last indicated the general presence of the beetle in many of the orchards where it had been liberated. Its rapid multiplication has been prevented, however, in many instances, by the submission of the orchards in question to spraying operations with lime, sulphur, and salt, or other washes, exterminating practically all of the scale food and hence leading to the starvation of many of the beetles. Nevertheless this imported insect has gained foothold and will probably make progress wherever scale food is abundant. Its spread by artificial distribution of colonies has been continued as far as material has been available. The discovery of the efficiency of the lime, sulphur, and salt wash, and the need in commercial orchards of absolutely clean fruit, will operate against this imported insect as against all other parasites of this scale. It is a comparatively easy matter and not expensive to keep an orchard

clean by spraying, and while this is the case it will not be advisable in commercial work to take the slower chance of clearing up by natural enemies, which can never be thorough from the very nature of the case. The successful establishment, however, of this Asiatic beetle in America can not work anything but good, as it is an important agency in the control of scale pests, and will become more efficient in America as it becomes more widespread and abundant.

The black-scale parasite in California (*Scutellista cyanea*) has exceeded in usefulness the most sanguine expectations, and has demonstrated that it can withstand the winter climate of California perfectly. The black scale of which it is an enemy is the worst pest of the citrus industry in southern California, and this imported parasite is the first agency which has offered any real hope of control other than by direct spraying or gassing operations. As an illustration of the prolificacy of this parasite, more than 40,000 specimens were distributed from the office of the Los Angeles County horticultural commissioners, and vast numbers were distributed from other centers.

The older importations of beneficial insects, such as the enemy of the white scale of citrous and other fruits in California and the *Rhizobius ventralis*, useful against the black scale in the moist regions of the Pacific coast, have continued their rôle of distinct usefulness, the first named being the most striking case of benefit ever made by an imported insect. The fig-fertilizing insect has enabled the raising of another very large and fine crop of Smyrna figs in the vicinity of Fresno, Cal., and the development of the fig industry seems perfectly assured, and only awaits the necessary lapse of time for new orchards to become established.

### SCALE INSECTS.

The work with scale insects has been actively prosecuted during the year. This group of insects includes some of the most important enemies of fruit trees and shrubbery, and in the South also of various field and garden crops. The small size of most of these scale insects, and the necessity of making careful microscopic preparations of them before determination can be made, render their identification by field observers difficult, if not impossible. The result is that a great deal of the work of determination comes to this Department from State entomologists and horticulturists, as well as from foreign sources.

### INSECTS DAMAGING FORESTS.

The work on tree pests is carried on in cooperation with the Bureau of Forestry. During the present year it has related particularly to (1) insect damage in the forests of the Black Hills region, a continuation of the work begun in 1902; (2) an investigation of important timber trees in the State of Washington, particularly the western hemlock, highland spruce, red fir, and other conifers; (3) at the southern station (Tryon, N. C.), damage to the southern pine and cypress; (4) in the middle Appalachian station, damage to imported mahogany and other timber and lumber by introduced and native insects, and to hickory, oak, and hemlock by bark-beetles and tan-bark insects; (5) at the southwestern station (Flagstaff, Ariz.), damage to pine forests by bark-beetles. In the course of this work there has been considerable cooperation with lumbering companies and manufacturers of articles of

wood, importers of exotic woods, and forest rangers. The general information gained from this study and from laboratory work at Washington has greatly advanced the knowledge of forest insects and the means of controlling them.

### INSECTS INJURIOUS TO VEGETABLE CROPS AND TO FRUITS.

The work reported in previous years has been continued in these two important fields of investigation. A subject of special study during the year has been the insect enemies of sugar beets, covering work done from Nebraska and Michigan to the Pacific Coast States and Arizona, with the object of issuing a comprehensive report on the subject. Work on the insect enemies of the orchard fruits, citrous and deciduous, and small fruits has been continued. The cranberry insects have been made the subject of a special publication.

### MISCELLANEOUS WORK WITH INSECT PESTS.

A good deal of work has been done during the year in the study of means of controlling damage by insect enemies of stored grains, such as the flour beetles and meal worms, and particularly of the Mediterranean flour moth, one of the worst of mill pests, which has been reported during the year in many new localities, from New York to California.

Insects affecting shade trees and ornamental plants have been studied, as also the important insect enemies of hothouse plants and indoor cultures.

The investigation of insects in relation to the health of man has been continued. The geographical distribution of the yellow-fever mosquito in the United States has been the subject of special investigation, as having an important bearing upon quarantine measures.

A special study has been undertaken of rice insects in South Carolina in cooperation with the South Carolina experiment station.

### INSECT ENEMIES OF GRAINS AND FORAGE PLANTS.

An elaborate investigation of insects affecting grains, grasses, and other field crops has been begun, and a special field agent of wide experience and reputation has been put in charge, with assistants and means for the best work. A further investigation will be immediately undertaken of the Hessian fly, the chinch bug, and the cutworms and wireworms and other insects affecting wheat, corn, clover, alfalfa, and similar crops. The damage by insects in this field is greater than in any other on account of the enormous areas under cultivation and the money value of the product.

### EXPERIMENTAL WORK WITH INSECTICIDES.

The most important results confirmed by the experimentation of the year with insecticides relate to the use of the lime, sulphur, and salt wash against the San Jose scale. Experimentation with this wash, long used in California against this scale pest, has been going on in the East for several years, and the results now secured have fully demonstrated its very great value in spite of the somewhat

adverse climatic conditions which obtain on the Atlantic seaboard and in the Mississippi Valley. It is a winter application, and very inexpensive as compared with the use of oils and soaps, means hitherto very much employed in the East, and it has the additional very distinct advantage of notable value as a fungicide; so much so in fact that some fruit growers are spraying their peach orchards with this wash, whether they have scale on them or not, simply for its value against leaf curl and other fungi. The usefulness of this wash has very largely decreased the terror which fruit growers have hitherto felt for the San Jose scale.

The possible value of sulphate of copper as a means of controlling mosquitoes, as indicated in a report issued by the office of Vegetable Pathological and Physiological Investigations of the Bureau of Plant Industry toward the close of the year, caused a series of experiments to be instituted by the Entomologist to test the usefulness of this chemical as a means of destroying such larvæ. The results of these tests have shown that it has comparatively small value against mosquito larvæ under normal outdoor conditions of breeding, but it may prove to be quite effective against mosquitoes in regions where water is kept in cisterns or small storage reservoirs, as, for example, in Cuba and in Panama. The experimentation with this substance is still in progress.

An expert has been put in particular charge of all investigations with insecticides and machinery, and the opportunity for practical work has been very much increased. Experiments are now under way with the insecticides referred to above, and also with petroleum oils; also fumigation experiments on fruit stock and buildings and granaries, and work on the composition of insecticides in cooperation with the Bureau of Chemistry are being carried on.

### ENTOMOLOGICAL EXHIBIT AT THE LOUISIANA PURCHASE EXPOSITION.

An elaborate exhibit of the work of the Bureau of Entomology was made during the year for the Louisiana Purchase Exposition—undoubtedly the most extensive and interesting exhibit ever sent out by this Bureau. It contains several entirely novel features of great educational value, and comprises very many cases indicating the life histories of injurious and other insects, together with large models of many of the principal injurious forms and vivaria in which injurious and beneficial insects are shown alive and at work.

### SILK CULTURE.

The work in silk culture has been prosecuted in all available lines. Silk reeling has been practically established with imported French reels and the temporary employment of French experts. Several American women have acquired the art of reeling silk, and a beginning has been made in the training of experts in this line of work. The importation of eggs and their distribution to all applicants has been continued; also of mulberry cuttings and rooted plants.

As pointed out in my last report, the establishment of the silk industry in the United States must be a matter of slow accomplishment. The distribution of mulberry cuttings and of silkworm eggs to those

who already have mulberry trees at hand should be continued. Eventually enough mulberry trees will be planted to insure a supply of food for a large crop of worms. Numbers of people will also have become familiar with the methods of silk raising, and conditions will then be ripe for the establishment of commercial filatures. In the meantime and under the existing conditions the establishment of some sort of market for cocoons is necessary; and it is for this reason that this Bureau, out of its appropriations, is buying and reeling a crop of cocoons which, though small at present, will increase as the work progresses from year to year.

### BEE CULTURE.

In bee culture comparative tests have been continued with the Caucasian and other types of bees and various crosses between these types themselves, in an effort to improve the domestic hive bee and secure certain varieties of special merit for different regions. The general conclusion reached is that the Caucasian race is by far the gentlest that has ever been brought to this country, and lends itself to manipulation and handling without the use of bee veil, and generally without smoke. These bees also are excellent honey gatherers.

The frequent statements that comb honey can be artificially manufactured have been shown to be absolutely false, and the purchaser who gets his honey in the comb may rest assured that he is getting an article manipulated at least by bees.

A special investigation has been made of bee conditions over a considerable area comprising the Middle West and Western States, with the idea to familiarize the expert with the conditions in these regions and to determine the feasibility and the desirability of the importation and establishment of foreign honey-producing plants.

A model apiary of 50 or 60 colonies of bees has been secured, and it is proposed to establish it on the Arlington Experimental Farm as a basis for apiarian investigations and as a breeding station of races and types of bees. The importation of foreign queens of different races has been continued, and studies have been made of honey-producing plants, methods of wintering bees, and bee diseases.

## BIOLOGICAL SURVEY.

As heretofore, the work of the Biological Survey has been conducted along the three lines laid down by Congress: (1) Investigations relating to the geographic distribution of animals and plants, including biological surveys and the determination of the life and crop belts; (2) investigations of the economic relations of birds to agriculture; (3) supervision of matters relating to game preservation and protection and the importation of foreign birds and animals.

### GEOGRAPHIC DISTRIBUTION.

The Biological Survey is engaged in mapping the natural life zones and crop belts of the country for the primary purpose of aiding the farmer to decide what crops are likely to prove a commercial success in his locality. The work is done by studying the geographic distri-

bution of native animals and plants in all parts of the country, and platting the results on maps showing the distribution of each species. In order to obtain the necessary data the status of the various species must be determined by office study and their ranges laboriously worked out in the field. The progress already made is gratifying, and a large number of maps are now approaching completion. The individual-species maps serve as the basis of a composite map showing the natural transcontinental belts and their more important subdivisions.

During the current year field work has been carried on over wide areas in California, Texas, New Mexico, Colorado, and Alaska. In California the field operations, for the purpose of securing data for a detailed map of the life and crop zones of the State, have been continued under the personal direction of the Chief. The field parties have practically completed work in western Texas, and are now in New Mexico. Explorations in Alaska have been continued among the northern spurs of the Rocky Mountains, about the upper and middle Yukon, and on some of the islands of southeastern Alaska.

### ECONOMIC ORNITHOLOGY.

In the section of economic ornithology, as in previous years, both laboratory work and field observations have been carried on. Orchards, gardens, and grain fields have been visited for the purpose of determining whether the birds damage crops, attack injurious insects, or devote their energies mainly to the wild fruits and weed seeds of the neighborhood; and collections have been made of food materials, including wild fruits, berries, seeds, and insects to assist in the work of determination in the laboratory. During the current year examinations have been made of 2,189 bird stomachs.

In studying the food habits of California birds, with reference both to the damage they inflict upon fruit and the good they do in destroying noxious weeds and insects, a scientist spent seven months (February to October) in the State, interviewing many of the fruit growers and visiting the most important fruit-growing sections. Most of his work was in the orchards, where the actual mischief done by the birds was noted and specimens collected.

In cooperation with the University of California, a study was made of the restrictive influences exercised by birds upon the increase of the well-known and very destructive codling moth. As a result, it was found that the pupæ of the moth are searched out and fed upon to a considerable extent by the black-headed grosbeak (*Zamelodia melanocephala*) and the Bullock oriole (*Icterus bullocki*)—two of the handsomest and commonest song birds of California. Other investigations were made in the same State regarding the supposed injury done by birds to bee keepers. Examinations of many stomachs of birds shot near bee-hives showed in nearly all cases that if bees are eaten at all the ones selected are the males or drones. A careful study of the food habits of the quail or bobwhite made during the year has demonstrated beyond question that from an economic point of view it is one of the most valuable of North American birds. Some of the insect pests eaten by it are the cotton boll weevil, potato bug, chinch bug, wire-worm, cut-worms of various kinds, and the cotton bollworm.

### BIRD MIGRATION.

During the year the usual spring and fall migration schedules were sent to and received from the regular observers and filed for future use. Sixteen thousand notes relating to the migration of warblers north of the Ohio and Potomac rivers were selected and arranged to complete a bulletin on North American warblers. This bulletin is now passing through the press. Work was also commenced on a study of the relations of migration and the weather by comparing the time of spring arrivals with the temperature at the place of arrival and in the region to the southward.

### GAME PROTECTION AND INTRODUCTION.

#### ENTRY OF FOREIGN BIRDS AND ANIMALS.

Constant vigilance is necessary to prevent the introduction into the United States of birds or animals that are likely to become pests. No species, therefore, except a few that are well known and harmless, are allowed to enter this country without a special permit from the Department. And, as an additional safeguard, careful inspection is made whenever through the large size of the consignment or other cause there is any apparent danger that undesirable species may slip in. The permits issued during the year numbered 318 and allowed the entry of 1,470 mammals, 205,400 canaries, and 41,630 miscellaneous birds. Most of the canaries and a large part of the miscellaneous birds came in at New York and were examined by inspectors at that port. Several importations were made of birds intended for liberation, among them 65 capercailzie from Sweden, brought in at New York and destined for the stocking of Algonquin Park, Ontario; 40 Mexican quail, liberated at various points in California by the board of fish commissioners of that State; and 366 European song-birds—goldfinches, bullfinches, larks, and robins—turned loose in British Columbia. Permits were also issued for the entry of about 3,000 eggs of partridges and pheasants.

#### INTERSTATE COMMERCE IN GAME.

Since the passage of the Lacey Act in 1900, 42 convictions for illegal traffic in game have been secured in cases passing through this Department. Of these, 26 were tried in Federal courts, 16 in State courts. During the past year 10 cases, involving the shipment of 700 birds and 36 rabbits, were reported to the Department. Six convictions were secured, one of which involved the longest distance shipment thus far taken up—from St. Paul, Minn., to Portland, Oreg. In order to expedite cases arising under the Lacey Act, State wardens have been advised to present their evidence direct to the Federal courts instead of referring it through this Department and the Department of Justice. This advice has been followed in two or three instances within the past few months, and indictments have been much more promptly secured in consequence.

Limited available resources have, as heretofore, made it necessary to concentrate efforts in two or three areas, and in all cases prevention of shipment has been given precedence over prosecution after

shipment has occurred. The passage of laws by Texas in 1903, prohibiting sale and capture of waterfowl, made it possible for the first time to restrict the enormous destruction of ducks in that State for Northern markets. Through local authorities and express companies general attention was called to the provisions of the State and Federal laws and a close watch maintained on usual shipping routes. No violation of the law was noted, and it is probable few consignments of ducks reached Northern markets from this State during the year.

An attempt was made to ascertain the effectiveness of recent legislation prohibiting shipment and sale of game by means of a special investigation in cooperation with State wardens and others. The kinds and prices of game in the markets of a dozen or more important cities during Thanksgiving week were ascertained. That considerable progress has been made in enforcing shipping laws was conclusively shown; few prairie chickens were on sale in any Eastern markets, and in some instances prices three or four times as high as those of a few years ago were charged; pheasants were absent from the markets of several cities where they were formerly abundant; and at the opening of the season quail were unusually scarce, though later, when the routes of shipment still open were discovered by the trade, they became more abundant.

### PROTECTION OF GAME IN ALASKA.

The Alaska game law has accomplished the two main objects for which it was enacted: The shipment of deer hides has been stopped and the export of heads of big game as trophies has been curtailed. The protection of game has been as satisfactory as could be expected in so large a region and without wardens. A mistaken belief, however, that the law does not permit natives to kill game for food, coupled with objections to the presence of visiting sportsmen, particularly on the Kenai Peninsula, gave rise to considerable criticism of the law. This adverse feeling led to the introduction of a bill in the Senate to replace the present law with one doing away with all restrictions except a provision to limit the export of trophies and charge license fees of $25 to residents and $250 to nonresidents for such export. As the adjournment of Congress without definite action left this measure still pending, the Department deemed it advisable to suspend the issue of permits for the present except in very special cases. Early in June new regulations were issued extending some seasons, permitting unrestricted shipment of bearskins, and making other desirable changes.

### MISCELLANEOUS WORK.

A preserve for the elk presented to the Government by Miller and Lux was established in Tulare County, Cal., on the Middle Fork of the Kaweah River, just within the boundary of the Sequoia National Park.

On the Pelican Island reservation in Florida a warden has been maintained through the cooperation of the American Ornithologists' Union and the Department, and the pelicans on the island have been practically undisturbed.

As heretofore, special attention has been given to the duty imposed by the Lacey Act of collecting and disseminating information relating to the propagation, uses, and preservation of birds. The demand for

such information is widespread, and much time is devoted to gathering material and preparing it for publication.

### RECOMMENDATIONS.

The three distinct lines of work assigned to this Division could be conducted much more economically and effectively were the Division reorganized as a bureau of three divisions, each to have charge of one of these lines, and were a larger amount appropriated for the performance of the work. I have accordingly recommended such reorganization.

## BUREAU OF STATISTICS.

On July 1, 1903, the Division of Statistics of this Department, which is the oldest distinctively statistical agency of the Government, antedating by a score of years the creation of this Department, received the broader organization of a bureau.

As now organized the Bureau of Statistics includes a Division of Domestic Crop Reports, a Division of Foreign Markets, and a Miscellaneous Division, which conducts special investigations and collects statistics on rural economics. The work of the Division of Domestic Crop Reports forms the most conspicuous feature of the statistical work of the Department. It employs nearly two-thirds of the entire clerical force of the Bureau, and calls to its aid the public-spirited service of nearly 250,000 voluntary correspondents, whose painstaking service deserves grateful appreciation. The results of its investigations are published monthly in the Crop Reporter, of which over 1,300,000 copies were distributed during the year.

The general appreciation by the business and farming public of the value of the Department crop reports grows steadily. Criticism is not lacking. On the contrary, it is one of the curious features of this work that the more closely reports represent the actual facts and the wider the appreciation of their accuracy the more subject they become to criticism. This is undoubtedly due to the fact that as their general accuracy is more and more widely recognized they necessarily exercise a greater influence upon the markets, thus inevitably favoring or antagonizing, as the case may be, some of those who are engaged in the game of speculation in agricultural products.

This immediately attracts the adverse comments of the losers. This result is unavoidable, and is apparently the inevitable penalty the Department must pay for issuing reports so reliable and so generally appreciated as to have instant effect on the markets. Were the reverse true, and were these reports regarded as unreliable, they would not influence prices, and criticisms would be reduced to a minimum.

The Bureau is earnestly engaged in studying the efforts of numerous associations of cotton manufacturers organized in several European countries for the purpose of promoting the production of cotton in new lands, with a view to rendering them more or less independent of the American cotton grower. These efforts are being especially directed to the interior of Africa. Before long it is thought that the Department will be able to publish some valuable matter on this interesting subject.

The production and international movement of grain in the principal European countries is another subject which is receiving the earnest attention of the Division of Foreign Markets.

With the assistance of experts newly engaged, the rice and truck crops will for the first time be made the subjects of systematic and continuous statistical investigation. The grain belt has been redistricted and an additional field agent assigned to it.

## OFFICE OF PUBLIC ROAD INQUIRIES.

Popular interest in road improvement appears to be deeper and more widespread than ever before. This is evidenced by the work of improvement actually going on in nearly all sections, by the State road legislation, by the calls for the road literature issued by the Department, and by requests for the advice and cooperation of the Department in building object-lesson roads.

### COOPERATIVE FIELD WORK.

For greater convenience and efficiency in carrying on the field work of the Office of Public Road Inquiries the country has been somewhat roughly laid off into four main divisions, with a special agent in each. The work of these and other special agents in the field consists in collecting and disseminating useful information regarding roads and road building, conducting investigations and experiments, attending and addressing meetings, and representing the Department in cooperative object-lesson road work.

At several points in the South the Office of Public Road Inquiries has cooperated in the construction of experimental roads of a mixture of sand and clay, and the results have shown that, in the absence of stone and gravel, this mixture may often be used to great advantage. Other object-lesson roads were constructed, with the cooperation of the Office, in Arkansas, Ohio, Tennessee, Virginia, and West Virginia. These were in most cases first-class macadam roads. An especial effort has been made to keep accurate accounts of the work done in each case, and to report the operations and expenses in such detail as to make the work a source of instruction to all who may read the reports.

Reports from all sections of the country in which experimental and object-lesson roads have been built in previous years are unanimous in commending the character of the work done and testifying to its great influence for good.

It is intended that the work of the Office shall be continued along the present lines of helpfulness and extended so far as practicable, in order that its benefits may be most widely distributed.

### STATE ROAD LEGISLATION.

The most important feature in State road legislation of recent years is to be found in the adoption of the State-aid plan. This plan involves a recognition of the fact that road improvement is a matter of general as well as local interest. The inefficiency of the statute labor system of repairing roads, the unwillingness of the rural taxpayers to assume the heavy burdens necessary to the building of improved highways, the popular aversion to the issuance of bonds, and the lack of any

central authority capable of coordinating the efforts of local communities, have to a great extent paralyzed efforts to secure general improvement of rural highways. The State-aid plan is intended to counteract these depressing influences. It provides sufficient funds to give scope and system to the efforts for road improvement; it distributes the burden of expense so as to greatly relieve the rural taxpayers; and it stimulates action on the part of local communities, coordinates local effort, assures competent supervision, and secures results of permanence and value.

The main features of the State-aid plan as now adopted in a number of the States are (1) a State highway commission, and (2) annual appropriations from the State treasury to pay a fixed part of the expense for building good roads, the balance of the cost to be met by the counties, the towns, and the owners of property lying along the improved roads. In nearly all cases the initiative is with the local communities, and the work is done under local control, but according to plans and specifications which must be approved by the State highway commission.

In New Jersey, the pioneer State in the adoption of this plan, the State pays one-third of the cost and the counties two-thirds, part of the county's share being assessed against the towns, the annual State appropriation being $250,000. In New York the State provides for one-half the expense, while the counties must pay 35 per cent and the towns 15 per cent. In 1903 the legislature appropriated $600,000 as State aid. No two States have adopted exactly the same provisions. Since 1890, eleven States in all have provided for a greater or less degree of State aid. They are the six New England States, New York, New Jersey, Pennsylvania, Delaware, and Maryland. In a number of other States the plan is receiving favorable consideration.

## OFFICE OF EXPERIMENT STATIONS.

### PROGRESS OF THE EXPERIMENT STATIONS.

The agricultural experiment stations throughout the country are maintaining close relations with this Department and are seeking its cooperation in increasing measure. The Department is endeavoring to aid the stations so far as it can with a view to raising the general level of their work in the directions of scientific accuracy and practical usefulness and to bring the results of their experimental inquiries promptly and effectively to the attention of farmers throughout the United States. It is believed that the Federal funds given to the several States for the maintenance of agricultural experiment stations are now spent more fully for useful agricultural investigations than ever before and that the results obtained by the expenditure of these funds, combined with those contributed by a considerable number of the States, will compare very favorably in scientific thoroughness and practical effectiveness with the results obtained with equal expenditures of public funds for similar work elsewhere.

Under the system of State control of the planning and execution of the experimental operations of the State stations and under the liberal terms of the Hatch Act, through which the States are granted Federal funds for the partial maintenance of their stations, there is necessarily considerable diversity of opinion as regards the proper and wise

expenditure of these funds. This fact is often overlooked in criticisms of the work of our stations as related to their use of public funds. With the growth of intelligent public opinion in the several States regarding the most useful functions of the experiment stations, the grade of their work has been raised, and when once the local constituency of a station has understood the real purpose and importance of good agricultural investigations, there has been little difficulty in securing the adherence of the managers of that station to the spirit as well as the letter of the laws under which the station is conducted.

ADVICE AND COOPERATION FROM THE DEPARTMENT.

It has been the effort of this Department to set before the stations a high standard of efficiency and to exert steady pressure for the improvement of their work. The cases of clear departure from the law in the use of the public funds granted under the Hatch Act have been comparatively few, and in such cases this Department has insisted on such an adjustment of expenditures as would protect the Federal funds. In most instances of this kind the stations have had funds wholly subject to State authority which could be spent more freely than the Federal funds and so have easily adjusted their accounts to meet the requirements of the Hatch Act. In some cases this has not been practicable and loss of a portion of the Federal fund of the ensuing year has resulted. Not a year passes but that some stations are persuaded by this Department to forego expenditures of the Federal funds which under the terms of the Hatch Act they might technically insist they had a legal right to make but which after discussion they are convinced are not in the best interests of their work. Especially has there been effected a more liberal interpretation of the duties and responsibilities of the agricultural colleges toward the stations, which are organized as departments of research in these institutions. There are now only a few of these colleges where the narrow and short-sighted policy of dealing illiberally with the experiment stations is maintained, and this Department will not cease its efforts to bring about a change of view and action by such college authorities on this important matter.

As the amount and variety of the cooperation between the bureaus of this Department and the State experiment stations increase there arise from time to time questions of policy regarding the relations of the Department and the stations in such enterprises. To provide a regular agency for the discussion and adjustment of such matters, I have created during the past year a standing committee on cooperation, consisting of the Director of the Office of Experiment Stations and the Chiefs of the Bureaus of Plant Industry and Soils. Several conferences have already taken place between this committee and the executive committee of the Association of American Agricultural Colleges and Experiment Stations.

During the past year a movement looking to the increase of the funds granted by Congress for the use of the experiment stations has been inaugurated and legislation for this purpose is now pending. After a careful study of this matter in connection with the examination of the work and expenditures of the stations during the past two years, I am convinced that the demands on the stations for the extension of their work which have been aroused by their success in giving direct practical benefits to agriculture in all parts of the country can

not be met without increased funds and that they are in a position to make effective use of larger means than they now have at their command. Now that this matter is being publicly discussed and the details of legislation have not been decided, it seems proper to state that in the view of this Department it is highly important that in any further act which Congress may pass for the benefit of the agricultural experiment stations the Federal funds shall be explicitly granted for purposes of agricultural research, and the powers and duties of this Department as related to the supervision of those funds shall be clearly defined.

### STUDIES IN CHEESE MAKING.

As the work of the experiment stations advances from year to year experimental data accumulate in many lines, and from time to time results of great general importance come out of this extensive work. A good example of this at the present time is found in the investigations of the stations relating to cheese making. The importance of this in this country is shown by the fact that cheese production now amounts to 300,000,000 pounds a year, valued at approximately $30,000,000. Though cheese making is probably the oldest dairy industry, very little has been known regarding the principles on which it is based. For centuries it has been carried on largely by rule-of-thumb methods, and the reasons for the various processes and the exact nature of the changes brought about by them have been unknown to the cheese maker. He has been guided mainly by the traditions of his art and has depended upon the skill and judgment acquired through long experience.

Within the past ten years several of the experiment stations of this country have prosecuted systematic studies of cheese making with a view of determining the principles upon which it rests and the means of simplifying and improving its processes. Owing to the large number of factors involved the work has been difficult, and for a considerable time the progress was slow. Now, however, the accumulated results are of great practical value, and it may be fairly claimed not only that this great industry has been put on a rational basis, but also that the art of cheese making has been simplified and its processes can now be more easily controlled, so that good cheese can be more uniformly produced.

### GAINS IN USE OF FEEDING STUFFS.

The Office of Experiment Stations has recently published a summary of a large amount of work which the stations have done on questions relating to feeding stuffs. Some of the practical results of this work have been very important. The saving and use of corn fodder (stover), which was formerly so largely wasted over a large part of the country, is a striking illustration of this. Its value as a feeding stuff has been demonstrated, and the best means of utilizing it have been shown by the stations' work, and their continual agitation has brought about very great improvement in farm practice in this respect. At the nominal value of $1 a ton the corn stover crop of the United States would be worth at least $100,000,000. While it is not all utilized, much the larger share of it is, and the practice of doing this is steadily increasing.

The inspection of commercial and condimental feeding stuffs, brought about by the experiment stations, has already had the effect of largely holding in check the adulteration of these products and fraud in their sale. In a number of the States where the laws have been vigorously enforced by the stations inferior articles have been entirely driven out of the market, because farmers would not buy them unless they received the stations' stamp of approval.

## THE AGRICULTURAL COLLEGES.

The activity of the colleges in providing special buildings and laboratories for instruction in the different divisions of the science of agriculture continues unabated. Among the buildings of this nature recently completed are the $50,000 agricultural building in South Carolina, the $150,000 agricultural building of the University of Wisconsin, and the agronomy and animal husbandry judging pavilion and the farm mechanics building of the Iowa State College of Agriculture and the Mechanic Arts. The University of Nebraska is erecting a $60,000 building for its school of agriculture.

The appropriations of the year for new buildings at the colleges and for the maintenance of these institutions have also been very large. The State legislature of Virginia appropriated $165,000 for buildings, equipment, and improvements at the agricultural college. The Iowa college has an addition of $50,000 to its maintenance fund, an appropriation of $95,000 to complete the central building, $45,000 for a dairy building, and $10,000 for equipping it, $22,000 for a new dairy farm, and $7,000 for equipment, and $54,500 to begin the construction of a heating plant, with several minor items, including $15,000 annually for the experiment station. The College of Agriculture of Cornell University is now definitely organized under State support, with an appropriation of $250,000 for buildings and equipment. The Illinois College of Agriculture has appropriations for a building for beef cattle, $25,000; another for horticulture, $12,200, and for a storage building for agronomy, $12,500. Minnesota has appropriations aggregating $300,000 for building purposes, including, among other items, $218,000 for a main agricultural building.

There is increasing interest in the formulation of courses in rural engineering and the provision of special facilities for instruction in this important subject. Special attention is being given to instruction relating to the construction and use of farm machinery. The continued scarcity of farm labor in almost all of the agricultural regions in this country makes necessary the employment of farm machinery on even a more extensive scale than has hitherto prevailed. The total value of implements and machinery on farms in this country, according to the last census, was $761,261,500, an average of $133 per farm and of 90 cents per acre of farm land. Much of this machinery is elaborate and complicated in construction and requires mechanical skill and genius for its most efficient operation and care. In very many cases it is also essential that the farmer shall understand how to repair such machinery. It represents an important part of the farmer's invested capital upon which he must earn or pay interest. That there is an enormous waste of money due to neglect and unskillful handling of this part of the farm equipment must be obvious to any

one who has traveled through the regions where it is most used. The colleges can therefore do a very important work in training their students so that they will understand the construction, care, and most economical use of farm machinery.

The attendance at the land-grant colleges in 1903 aggregated 52,489 students, of whom 3,146 were in four-year courses in agriculture, and 7,550 in shorter courses in agriculture, dairying, horticulture, and veterinary science. The graduates of these institutions in 1903 were 4,524, and since their organization 53,252. The importance of the colleges of agriculture and mechanic arts as a part of the American system of higher education and research has been notably shown during the past year at the Louisiana Purchase Exposition, where an extensive exhibit of the work of these institutions was made in the Palace of Education.

### SECONDARY AND ELEMENTARY SCHOOLS.

Progress has been made during the year along the lines of secondary instruction in agriculture not only in the schools maintained in connection with the agricultural colleges, but also in separate secondary schools, the number of which is steadily increasing. Considerable attention is being given of late to the practical instruction of women along agricultural and horticultural lines.

The introduction of agricultural instruction into the primary schools is being more widely discussed than ever before at meetings of teachers and farmers. The success of the nature study and school garden movement in a considerable number of city and country schools has led to a demand for the more formal teaching of elementary agriculture in the higher grades of the rural schools. The National Educational Association, State superintendents of public instruction, officers of agricultural colleges, as well as a number of other organizations and numerous individuals in various official positions, have of late interested themselves in the introduction of elementary agriculture and gardening in these schools. The National Educational Association now has a special committee of educators of national repute considering this subject.

### METHODS AND TEXT-BOOKS.

At the recent convention of the Association of American Agricultural Colleges and Experiment Stations at Des Moines, Iowa, the standing committee on methods of teaching agriculture made a report in which it gave a brief history of the development of manual training and agricultural instruction in the common schools, and outlined a course of nature study and elementary agriculture for such schools. Outline courses in elementary agriculture have already been prepared by school officers in a number of States. These are supplemented by the formation of clubs of farmers' boys and girls, which are organized for the purpose of conducting simple experiments at their homes. Eight thousand Illinois boys belonging to these clubs exhibited corn of their own raising at the Louisiana Purchase Exposition. In a number of States laws have been enacted requiring teachers to pass examinations in agriculture, and the training of teachers along agricultural lines is already receiving considerable attention at agricultural colleges and schools, and normal schools, especially at sessions held

during the summer. A considerable impetus to the movement for the introduction of agriculture in the public schools has been given by the recent improvement of text-books and works of reference. Within the last year or two a number of elementary text-books in agriculture have been published, and some of these seem well suited to use in the rural schools. In one way or another thousands of children in the common schools are already receiving some instruction relating to agriculture, and the movement in this direction is rapidly increasing.

AID FROM THE DEPARTMENT.

This Department is aiding this movement so far as it can without having funds specifically for this purpose. It seems very desirable that the Department should be in a position to give more effective aid to the movement which contemplates the application of the results of practical and scientific investigations to our agriculture through instruction to multitudes of farmers' children in the public schools as well as in the agricultural colleges. The vast majority of teachers in rural schools throughout the country are unacquainted with the work and publications of this Department and do not understand how these publications might be utilized for instruction in subjects related to agriculture. Very much needs to be done to overcome the prejudice of school officers and teachers against the introduction of agricultural subjects into the schools. It is becoming increasingly clear that the results of the work of this Department and the experiment stations can not be most effectively and widely utilized by our farmers unless in early life they are taught to think and act along the lines in which the application of scientific principles and discoveries is made to appear theoretically rational as well as practically useful. Therefore, to secure the greatest benefit to our agricultural people through the expenditure of public funds in the maintenance of this Department and the experiment stations, we should be able to bring the work of these institutions directly to the attention of our educators and school managers in every State and Territory.

FARMERS' INSTITUTES.

Work in the interests of the farmers' institutes throughout the country has been regularly organized in the Office of Experiment Stations. Special efforts are being made to aid the large force of lecturers who are in the employ of the State directors of institutes. The attention of these lecturers has been definitely called to the numerous publications which this Department and the experiment stations are issuing, which will be useful to them in their institute work, and they have been put in the way of receiving these publications regularly.

There is also a growing movement for the establishment of the institutes in the several States on a more permanent basis. The form of organization most approved is that of a strong local permanent organization in each institute district, combined with a system of oversight and limited control by the central State authority, whose duties and powers are prescribed by law.

ALASKA EXPERIMENT STATIONS.

During the past year experiment stations were maintained at Sitka, Kenai, Rampart, and Copper Center, and cooperative experiments were

conducted at Wood Island. Seeds of vegetables and flowers were distributed through the cooperation of the Bureau of Plant Industry to about 1,500 addresses. Many of the recipients report success and further confirm the possibility of raising hardy vegetables and hardy annual flowers in nearly all parts of the Territory south of the Arctic Circle. An investigation of the grasses and forage plants of Alaska is being conducted in connection with the Bureau of Plant Industry. At Sitka the headquarters building has been completed in accordance with the plans furnished by this Department, except for some minor alterations made in the interests of economy. More attention will hereafter be given at this station to horticulture and the propagation of trees and bushes for distribution to the other stations and over the Territory at large. Some nursery stock consisting of hardy and early maturing varieties of apples, plums, and cherries have been planted, and currants, gooseberries, and raspberries are also being propagated.

### SOME RESULTS OF THE WORK AT THE STATIONS.

At the Kenai station about 21 acres have been brought under cultivation. Experience during the past two seasons at this point has shown that the maturing of grain is somewhat uncertain, though an abundance of forage can be grown every year. Cattle do well here, and the station is beginning in a small way to build up a herd.

At the Copper River Valley station, opened two years ago, a number of acres have been cleared and cultivated. During the season of 1903 barley and oats matured, and produced plump and heavy grain. Cultivated grasses seeded in experimental plats did well, and a considerable variety of hardy vegetables were grown. In 1904 an elaborate system of plants has been laid out and extensive experiments are under way with cereals. During August a severe frost destroyed many varieties of the cereals, rendering them fit only for hay, but some barley was matured and the grain saved for seed, and about 90 per cent of the Sixty Day and Finnish Black oats were matured, making about an average crop. This station has the first equipment of farm implements brought into the interior of Alaska. A number of small tracts have been cleared by settlers and are under cultivation at various points throughout the valley.

At the Rampart station grain matured in 1902 and 1903, and for this reason more extensive experiments have been conducted during the past year, and barley, oats, and rye have been successfully grown.

In general the experimental work in Alaska has shown that live stock may be successfully maintained at many points in the Territory. The special agent in charge of the Alaska stations urges the desirability of securing breeds of sheep and cattle better adapted to the climate of Alaska than those which have hitherto been maintained there. It is, however, impracticable to carry on experiments with animals in any large way with the present funds at the disposal of the stations.

### GRASS LANDS AND LIVE STOCK.

There are on the southern coast of Alaska, from Cook Inlet to Unalaska, about 10,000 square miles of grass lands, over one-half of which are capable of utilization. On much of this land there is a luxuriant growth of grasses often 6 feet high; on the remainder, lying at

higher elevations and in more exposed situations, the grasses are too short for hay cutting, but furnish splendid pasturage. That these grasses are nutritious the fat and sleek condition of the cattle furnishes ocular demonstration.

At the present time this great resource is practically untouched, though there are small herds of milch cows at most of the towns and villages. Recently a live-stock company has begun operations with cattle and sheep on Kodiak Island and another company is making actual preparations to utilize Akutan Island.

It is possible for both sheep and cattle to live throughout the winter without care, as has often been demonstrated. Indeed, where cows belong to the natives they are forced to live through the winter with little or no care, eking out an existence by feeding on browse and seaweeds. Milch cows kept by whites are as a rule fed from five to six months, and this may fairly be considered the length of time when animals require feed and shelter.

Sheep raising has thus far not proved successful. The principal trouble seems to have been that the animals were of breeds not adapted to the conditions that prevail on the Alaska coast. In both cases where trials have been made grade animals were imported from the semiarid regions of California and Oregon, where the climate is well-nigh the antithesis of that in Alaska. With other breeds success is not at all unlikely to follow.

For three reasons I am impelled to believe that the Alaska grass lands as a whole can be most profitably utilized at present through dairying. First, because the small population of the Alaska coast limits the market for beef to a small fraction of the possible yield. Second, because of the necessarily long feeding period, five or six months, during which only dairy cattle will yield compensating returns. Third, because the freight to distant markets on concentrated products like butter and cheese is not a serious factor.

The Alaska coast furnishes many admirable sites for dairy colonies or settlements, both on the islands and on the mainland. With such a great wealth of grass as southwestern Alaska possesses it is difficult to believe that it will not become a great dairy country. It is doubtful if equally good opportunities for colonies of dairymen can be found in the United States to-day. Certainly there is no other place left where 320-acre homesteads of magnificent grass lands can be had for the taking. In view of the enormous area of these lands, it seems most advisable that this undeveloped resource be converted into wealth. Perhaps nothing will stimulate this as much as practical experiments and demonstrations by the Department of Agriculture.

### HAWAII EXPERIMENT STATION.

A chemist and horticulturist have been added to the staff of the Hawaii station, and in this way the field of operations has been considerably widened. Soil investigations have been undertaken by the chemist, which are of general importance to the agriculture of the islands. The horticulturist has prepared a bulletin on bananas, which not only treats of the cultivation and marketing of this fruit, but also brings together descriptions of a large number of Hawaiian varieties, making possible a systematic study of this important food plant. Experiments are being continued on the cultivation and fertilization of

bananas, and a large collection of varieties is being brought together on the station grounds. Experiments in the propagation of mangoes and alligator pears have been begun.

The entomologist has prepared a bulletin on the leaf hopper of sugar cane, which was investigated at the solicitation of many of the planters of the islands. This insect made its appearance quite recently and has proved in certain districts to be a very serious enemy to cane cultivation. The bulletin treats of the life history of the pest, describes the injury produced, and offers suggestions for its control.

Under the immediate direction of the special agent in charge, investigations have been made of some of the fungous diseases of coffee, sugar cane, and other economic plants, and a comparative test of grasses and forage plants has been begun in connection with the Hawaii Live Stock Breeders' Association. Cooperative experiments with tobacco have been conducted on the island of Hawaii with the object of producing a type of tobacco that is especially adapted to Hawaiian conditions. Cooperative experiments on cacao and banana cultivation are also being carried on in connection with the insular board of agriculture and the Hilo boarding school.

### PORTO RICO EXPERIMENT STATION.

The work of the Porto Rico experiment station has been considerably enlarged during the past year, partly with the aid of an appropriation of $2,700 made by the insular legislature and nearly $1,200 received from the sale of farm products.

Many permanent improvements have been made on the station farm. A small tile machine was purchased and drain pipes were manufactured on the farm. Practically all the river bottom or alluvial land on the station farm has been drained. This is the first underdrainage ever undertaken in Porto Rico, and it is believed that it will not only greatly enhance the producing power of the station property, but will also serve as a valuable object lesson to the planters of the island. An experimental irrigation system has also been installed on this farm.

A preliminary survey of the principal tobacco districts of the island has been made by a tobacco specialist in the employ of the station, and a report on these investigations is being prepared.

The investigations on different methods of pruning, shading, and fertilizing coffee plants have been continued. An attempt to exterminate the coffee-leaf miner by hand picking the leaves proved the impracticability of this method of repressing this pest. The entomologist of the station has also been investigating the possibility of combating this insect by means of parasites, and reports the discovery of an effective parasite which, it is believed, by careful propagation and distribution, will aid very materially in keeping in check this insect, which is by far the most serious enemy to coffee cultivation now upon the island.

A special study of the diseases of coffee and other plants was made by the botanist of the Connecticut State experiment station, who was temporarily in the employ of the Porto Rico station.

Much attention is being given to the propagation of citrous fruits, especially with a view of obtaining better stock for growing in the orchards of Porto Rico. A bulletin on the methods of production and

marketing of oranges, with special reference to Porto Rico conditions, has recently been issued. A large number of tropical fruits, including mango, alligator pear, soursop, nispero, guava, and many others, have been brought together in a tropical fruit orchard.

The tea, rubber, and cacao plantations mentioned in my last report are flourishing and are being extended. Among the tropical vegetables which enter into the variety tests are the yautia, taro, edible canna, arrowroot, cassava, yams, and sweet potatoes, all of which have thus far done well.

Experiments are being carried on with a number of fiber plants. Among these, maguey and sisal have thus far given very promising results. The station has thus far conducted no careful experiments with cotton, but the industry has been extended throughout the island to a considerable extent during the past year, and the station officers report that the results seem to indicate that it is possible to profitably produce a medium grade of Sea Island cotton in Porto Rico.

The report of the Bureau of Soils on the soil survey from Arecibo to Ponce, made by that Bureau in cooperation with the Porto Rico station, has been reprinted in both English and Spanish for distribution on the island. Several other bulletins and circulars in both languages have been issued during the year.

### PROPOSED EXPERIMENT STATION AT GUAM.

This Department has recently received a request from the governor of Guam for the establishment of an agricultural experiment station on that island. In making this request the governor states that the population of the island, consisting of about 11,000 people, and increasing at the rate of about 3 per cent a year since the American occupation, is devoted entirely to agriculture. The farms, which are small, are located in the hills back of the surrounding towns, and the people usually go to them in the early morning, returning to their domiciles at night. As they are devoted to tilling the ground and the raising of fruits, and to nothing else, this is an especially good field for the introduction of such additional fruits and vegetables as only the resources of the Government can command. The revenues of the island are insignificant, so that the people can not afford to pay anything toward an experiment station, although its influence will be very beneficial. There is a considerable tract in the public lands of the island which could be set aside for an experimental farm.

Since it seems quite important that the people of Guam should receive such aid in developing their agriculture as is now given by the Government to our other island possessions, I have recommended an appropriation of $5,000 for the maintenance of a station on this island in cooperation with the Navy Department.

### NUTRITION INVESTIGATIONS.

In the nutrition investigations steady progress has been made in the elaborate and fundamental inquiries regarding the laws of human nutrition with the respiration calorimeter, and in the more directly practical studies of the nutritive value of cereals, fruits, and meat. The great importance of these investigations is being recognized, not only by scientific and educational institutions throughout this country,

but also in many foreign countries. The constantly increasing number of requests for nutrition publications and for information from individuals, institutions, public schools, medical schools, and similar sources, is a proof that the results of the nutrition investigations excite wide interest and are appreciated.

The cooperative method by which the work of investigation has been distributed among various educational, scientific, and similar institutions in the United States has been productive of as excellent results the past year as hitherto, and a satisfactory amount of investigation has been conducted. This has been made possible in part by the generous support accorded by the cooperating institutions, which have contributed in some cases money, and in practically all cases the use of laboratories, apparatus, libraries, the advice and counsel of skilled experts, and similar assistance. Other institutions have expressed a readiness to join in such researches, provided a comparatively small amount can be allotted them, but with the funds at our command it has not been found possible to extend the inquiry beyond the present limits.

### CALORIMETER EXPERIMENTS.

The experiments with the respiration calorimeter during the past year have had to do principally with the comparative values of fat and carbohydrates as sources of energy. The apparatus has been so modified that a given quantity of air is circulated through the respiration chamber, the oxygen withdrawn by the subject being made good by the addition of a fresh supply, while the products of respiration are removed for measurement and analysis. This method of experimenting permits of direct measurements of the oxygen consumption in addition to other factors concerned with the metabolism of matter and energy, and represents a decided advance. In its present form the apparatus is fully as accurate as the form previously described and gives very satisfactory results. The form of apparatus which may be most advantageously used depends upon the character of the problem which is to be studied, since both the earlier type, in which a continuous quantity of air was pumped through the apparatus, and the present type, with the closed air circuit, furnish very accurate means of studying a large variety of problems which have to do with the fundamental laws of nutrition and practical questions connected with the satisfactory feeding of man and domestic animals.

### SPECIAL STUDIES OF THE YEAR.

During the year the experimental and editorial work connected with the dietary studies at the Government Hospital for the Insane has been completed and a bulletin describing the results in detail has just been published. The data secured are of great interest in themselves and will prove of material assistance in formulating dietary standards and in other ways, while the experience gained in conducting investigations will prove of great value in future work of a similar character. The studies showed that the diet at the Government hospital was well managed and that the food was abundant, of good quality, and well prepared. As the study progressed it became evident that in many ways economy in the preparation, handling, and storing of food might be introduced which would prevent waste and effect a considerable saving without making any radical change in the character

of the menu. In other words, it was evident that, as in all business enterprises, more careful and expert management would prove valuable.

The studies concerned with the nutritive value and digestibility of flours of different grades have furnished very interesting data and the material now accumulated seems sufficient for answering the much-discussed question as to the comparative value of different sorts of flour ground from a given lot of wheat. It seems fair to say that the grades of flour known as whole wheat and graham contain a somewhat larger proportion of protein and ash than the patent grades, but are inferior as regards the thoroughness with which they are digested. Judging, therefore, by the total material which the body receives, the various sorts of flour are practically equal in value. The mechanical effect which the coarser flours exercise on the digestive tract should not be overlooked.

The dietary studies and digestion experiments with Maine lumbermen have given some interesting and valuable results. In fixing upon dietary standards it was desirable to have data regarding the kinds and amounts of food consumed by persons performing severe work and leading a very active outdoor life. Such conditions were met in the Maine woods. The diet with which the lumbermen were provided was comparatively simple in character though generous in amount. Generally speaking, the quantities eaten were fairly large, furnishing an abundance of both protein and energy. The food was quite thoroughly digested, no difference being observed between these men and those living and working under more usual conditions.

At the University of California, the investigations concerning the nutritive value, digestibility, and place in the diet of fruits and nuts have been continued and important data are being accumulated. The bulletins already published, which report the results of these investigations, have been widely circulated, showing that there is a popular demand for information along these lines. A popular bulletin has been published showing how a surplus fruit supply may be used in the household for the preparation of jams, jellies, and similar products, a class of foods which may be made to supply carbohydrate material in a palatable and attractive form, while at the same time the acids and other bodies which the fruits contain are believed to exercise a beneficial effect on the system.

## IRRIGATION AND DRAINAGE INVESTIGATIONS.

### METHODS AND PROBLEMS.

During the past year the office of Irrigation and Drainage Investigations made a comprehensive study of the methods and cost of preparing land for irrigation. The results show the need of a better understanding of this subject by farmers. Much has been done by the Government and the States to aid engineers in the right planning of dams and canals, but farmers have not been aided in like measure in understanding how to get the best results out of the water when furnished. A bulletin published by the Department gives descriptions and illustrations of the tools used in grading land and building laterals and of the leading systems in use in distributing water in fields, orchards, and gardens. These studies show that the cost of preparing land for irrigation is far greater than has been realized, varying under

flooding from $2 to $5 an acre and under the check system from $8 to $25 an acre. Here is a large opportunity for saving money to farmers by aiding them in choosing the method best suited to their conditions.

Last year a working agreement was entered into with the Western experiment stations for the systematic collection of information on important features of irrigation practice, which will enable this Department promptly and at small cost to collect and disseminate information of great practical value. This year the subjects studied were the methods of measuring water, the rate of rise of soil water during the irrigation period, and the use of cement and concrete instead of wood in irrigation structures.

DUTY OF WATER AND APPLICATION TO SOIL.

The increasing value of water has given added importance to the studies of its duty, which have been a leading feature of this investigation from the outset. Rights which originally were purchased for $5 an acre now sell for $35 an acre. Annual water rentals have risen in certain districts from $1 to $7 an acre. Every extravagant appropriation of water is a direct incentive to waste, and excess contracts and decrees will continue to be made so long as the quantity actually used has not been determined by accurate impartial measurements. This fact is giving the work of the Department increasing importance. Its reports are being used in fixing water-right decrees, and measurements of the duty of water on streams where adjudications are proposed, are urgently requested.

Scarcity of water in the arid West makes it desirable that it shall be used by irrigators in the most economical and skillful way. To aid in making this possible the Department is carrying on a series of scientific studies to determine the quantity of water which will give the best results and the best method of applying it to crops. In one important irrigated district these measurements show that the quantity needed to irrigate 60 acres of land under the method in common use will irrigate 100 acres when applied by another equally feasible method. They also show that the time of irrigation and the quantity of water used have an important influence on the quality as well as on the yield of crops.

PUMPING WATER FOR CROPS.

During the past season records of the performance of over 2,000 irrigating pumping plants, scattered from Texas to Washington, have been obtained. These included many types of pumps operated by gasoline, crude oil, distillate, by steam generated by means of oil, coal, and wood, by electric motors, windmills, and water power. The rapid extension of pumping as a means of extending irrigation gives great practical importance to these studies.

Wind is one of the neglected but promising sources of power for providing water for irrigation and for doing other farm work. An arrangement has been made with the department of farm mechanics in the Iowa State College to supplement the field studies made during the year by more careful tests of the efficiency of different makes of windmills. The makers of these machines have manifested much interest in these investigations and have not only offered to supply

the mills needed for testing free of cost but to manufacture others according to any special design suggested by this Department.

Last season's pumping studies lead to the conclusion that there is a broad field for irrigation by pumping; that where the lift of water is less than 50 feet the number of failures are comparatively few. The failures noted have been due to two principal causes: Lack of mechanical knowledge or skill on the part of farmers needed to keep machinery in proper condition; and the selection of pumps of too great or too small capacity for the work to be done.

IRRIGATION IN THE HUMID SECTIONS OF THE UNITED STATES.

The studies of irrigation in Italy show that irrigation is highly profitable in a region having a larger rainfall than the Mississippi Valley, and there seems no doubt that in a similar way it is to have a large field of usefulness in the eastern and southern portions of the United States. One of the special crops which require irrigation is cranberries, and a cooperative arrangement has been made with the experiment station of Wisconsin and the Wisconsin Cranberry Growers' Association, under which the Department is attempting to formulate the principles which should govern the irrigation and drainage of cranberry beds. The studies made in Wisconsin are being supplemented by similar studies in New Jersey.

In the rice districts of Louisiana and Texas practically all the water used in irrigation has to be pumped. The quantity used and the performance of different types of pumps in providing it are controlling factors in the success of this industry. Both these have been studied during the past year.

There is a large territory in central Arkansas which is believed to be well suited to rice growing. The Department is cooperating with the State experiment station to ascertain whether it will pay in this section to pump water to irrigate rice. The results this year, while encouraging, show that it will require considerable experimental work to place the industry on an assured basis.

DRAINAGE INVESTIGATIONS.

Crop production is being extended in this country in three ways—(1) by reclaiming, through irrigation and drainage, lands hitherto worthless or yielding only a nominal return; (2) by improving soil conditions in lands already under cultivation; (3) by scientific rotation and intensive cultivation of crops.

Since soil drainage is an important factor in all of these, the promotion of practical and efficient methods may do much for the general improvement of agriculture. Original investigation, combined with careful scrutiny of current practice in this and other countries, will enable this Department to place before State and district authorities, cultivators, and landowners the methods and practices suited to their conditions.

The following work was carried on during the year:

(1) An examination of some of the irrigated lands of Utah for which drainage is urgently needed, the giving of advice concerning plans, and the beginning of some experiments in tile drainage to determine the operation of underdrains in certain soils.

(2) The examination of several large drainage projects in the Middle West, in company with engineers, county boards, and interested land-

owners, followed by reports and recommendations of plans. About 400,000 acres of land are affected by these projects, with an estimated outlay for drainage of $1,000,000.

(3) Collecting and classifying field data upon the construction of levées for protection of river bottom lands; their ditching and drainage by pumps; construction, duty, and operation of land dredges; the construction and behavior of drainage ditches of various sizes.

(4) Collection of data regarding the operation of the older systems of tile drainage in the Middle West, with respect to determining how far conditions may be improved by reconstruction.

A preliminary examination of a portion of the Everglades in Dade County, Fla., was made in conjunction with the Bureau of Plant Industry, and it is thought that the Everglade soil can be made profitable for growing subtropical fruits if it can be sufficiently drained. In view of the interest taken in growing fruit and vegetables in southern Florida for the Northern winter markets, the reclamation of the Everglades merits further attention.

The lines of work carried on during the present year indicate the widening importance of this branch of agricultural improvement. The condition of much of the farming land in the older irrigated districts, and especially in Utah, demands prompt and active relief through drainage, or the loss already suffered by bogging of the land will be rapidly augmented. The Department can render great assistance to the people of these sections by enabling experts to direct and assist in starting practical drainage operations in localities where farmers are ready to begin.

An entirely different class of problems has been encountered in connection with the drainage of the peat swamp lands of central Wisconsin. Here the assistance of the experts of the Department has been requested in order to determine the manner in which drainage should be accomplished and regulated during the subsequent treatment of these marshes.

The reclamation of tidal marshes is a subject upon which numerous inquiries have been received and which may be profitably studied.

The further development of the prairie lands of Arkansas and the heavy cotton lands of Mississippi will depend upon the introduction of more thorough methods of drainage. There is no public information available bearing directly on the treatment of the drainage problems there encountered, although it is a fundamental matter in the development of certain lands in these States.

The drainage experts of the Department have given considerable time and thought in advising with and aiding agricultural colleges and stations about courses of instruction in drainage engineering and the carrying out of experiments in drainage. The establishment of these courses of study and the special training of men to carry out this branch of farm improvement promise much for the betterment of soil conditions and soil production in future years. The success of these classes is shown by the fact that Illinois has 42 and Iowa 65 students at present enrolled in drainage engineering.

### AGRICULTURAL ENGINEERING.

The valuable results which have come from including irrigation and drainage in the work of the Department leads me to believe that this

investigation should include two other branches of agricultural engineering with which they have a close relation. These are farm buildings and farm machinery.

That this Department should give some attention to the convenience and healthfulness of farmhouses and farm buildings would not seem to require any argument. These have such vital relation to the attractiveness and profits of farming and to the improvement of the social and industrial conditions of farm life that they ought not to be ignored by this Department.

There is urgent need of study of the important question of ventilation and lighting in farm barns. A recent investigation carried on by the Agricultural College of Wisconsin has shown that scores of costly barns, intended to house valuable blooded live stock, and on which thousands of dollars have been expended to secure perfect sanitary conditions, are a complete failure so far as ventilation is concerned; and that this lack of proper ventilation is causing serious increase in the spread of tuberculosis and seriously impairs the profits of feeding. Hundreds of farmers are delaying the building of barns because, while they realize the nature of the difficulty and the necessity for its remedy, they do not know how to accomplish it. It is a striking but admitted fact that we are so ignorant of the proper principles of barn ventilation that many of the costliest structures built in recent years have been the most defective in this regard.

There is another reason for this Department giving some attention to the subject of farm buildings. We are entering a transition period in which the cheap wood construction of former years is giving way to permanent structures of stone, concrete, and iron. Farm houses, through better water supplies, plumbing, and sanitation, are being made as convenient as those of the city. The working out of these changes involves so many new problems that the Department is being called upon by experiment stations, improvement associations, and communities for advice and information which if furnished could not but result in a marked improvement in the conditions of farm life.

### MACHINERY AND MOTIVE POWER.

Closely related to the healthfulness, convenience, and cheapness of farm buildings is the right selection, care, and use of farm machinery. The studies of pumping machinery have shown that the most important factor in its successful use is the mechanical skill of the farmer, and we are beginning to understand that the increased complexity and cost of farm machinery make the education of the American farmer along these lines more and more desirable.

No more significant change is taking place in American agriculture than the extent to which different kinds of motive power are taking the place of men and animals. The use of the traction engine and automobile in the place of the horse on the country roads, the employment of gasoline, steam, wind, and electric power to operate mowers, threshers, plows, feed cutters, corn huskers, and dairy machinery are illustrations of epoch-making changes that are now going on on every modern American farm. On one ranch in California there is $60,000 worth of farm machinery operated by some other power than animals or man. For want of proper information these changes are involving farmers in serious mistakes and large losses. They buy motors not

suited to their requirements or which they do not know how to operate. They buy machinery not adapted to their condition and cause its rapid destruction by not knowing how to care for it.

There is made and sold each year in this country about $100,000,000 worth of farm machinery. Fully one-half of this goes into the hands of men who do not know how to select it wisely or to keep it in proper condition. The waste which results runs into millions of dollars annually. In addition, implement manufacturers lose large sums in making and attempting to introduce machinery unsuited to the work it is intended to perform, with a resultant loss to both farmers and manufacturers.

Realizing the need of improvement in these matters, and partly to meet the requests of implement manufacturers for young men having agricultural and mechanical training which will enable them to design and construct implements suited to the conditions of the American farm, a number of agricultural colleges and experiment stations have inaugurated courses of instruction and begun systematic experimentation for the purpose of bringing about a general diffusion of intelligence about this feature of farm work. They have appealed to this Department for aid in this work similar to that already given them in other lines of agricultural investigation.

### TESTS OF CORN PLANTERS AND WINDMILLS.

As illustrating the important results which are destined to come from the inauguration of this work, one of the results of an investigation carried out by the Iowa State College, a pioneer in this line of education and experimentation, will be given. It began its study of farm machinery with the operation of corn planters, because no single factor contributes more to the yield than securing a uniform stand, and this is impossible if the seed is not planted evenly. The machines for planting corn in hills are intended to drop from three to four grains, yet farmers have been buying, and implement makers manufacturing and selling, planters without any definite knowledge as to how they behave in this respect. In making this test all of the leading machines were included. It brought out the following significant facts:

(1) That no planter now made will drop evenly unless the grains have been graded. The introduction of seed-grain graders followed, and was an immediate, important, practical gain to agriculture and to manufacturers of this kind of machinery.

(2) That with graded grain certain types of machines do accurate work.

(3) That other types will not drop evenly under any conditions.

The important and encouraging feature of this investigation has been the interest shown by manufacturers who have accepted the results as impartial and conclusive. Makers of machines found defective were as ready to accept the results as the makers of those which operated properly, the defects being at once corrected.

The test of windmills by the Iowa State College to determine the designs and sizes best suited to lifting water for irrigation promises to lead to important results in extending the use of this motive power in grinding grain, handling and storing produce, and doing some other kinds of farm work practically without expense, which formerly required a considerable expenditure for man or animal power.

NEED OF AN EXPERT IN FARM BUILDINGS AND MACHINERY.

The requests of the colleges and stations for aid in carrying out these investigations and in planning courses of instruction have been supplemented by numerous similar requests from farmers for advice and assistance about the selection and operation of different kinds of farm motors and other farm machinery. In the absence of any special arrangement for dealing with these problems, they have been referred to the Office of Experiment Stations and dealt with by the Irrigation and Drainage division of that Office; but there are at present no funds which can be utilized for systematic work along these lines. I am of the opinion that results of great value, alike to the farmers and the manufacturers of agricultural machinery, will come from the extension of the Department's work in agricultural engineering to include studies of this character, in cooperation with the agricultural colleges and experiment stations. I have, therefore, asked Congress for an appropriation which will enable us to employ an expert in farm buildings and farm machinery, in connection with the irrigation and drainage investigations.

## DIVISION OF PUBLICATIONS.

The publication work of the Department is a faithful reflex of its activity and growth. The diffusion of the valuable information acquired by the Department is effected almost entirely through this medium. The time was, indeed, when in spite of the comparatively few publications issued, the cost of printing them amounted to far more than half the entire expenses of the Department. At present the entire cost of this work is not even one-sixth of the total expenditures of the Department, and yet the number of publications issued during the past fiscal year aggregated 972. Of these, 379 were new, comprising about 23,000 pages of matter. The number of copies of all publications issued during the year aggregated 12,421,386. The 600 reprints attest forcibly the extent of the demand for the Department publications.

Of the whole number printed 415 were Farmers' Bulletins, of which 25 were new and 390 reprints. The total number of copies of these issued during the year was about 6¼ million, very nearly 5 million being distributed upon the orders of Senators, Representatives, and Delegates in Congress.

A very gratifying feature reported by the Department Editor is the constantly increasing demand for the Department publications by educational institutions, mainly for class work. This has added, however, very much to the demands made upon us, and, unfortunately, has greatly increased the instances where it has been found impossible to comply with applicants' requests owing to the exhaustion of the supply.

This suggests the possibility, with the cooperation of Congress, of utilizing, after sufficient time has elapsed, a portion of the unused Congressional quotas of many of our documents. If some plan could be devised, with the approval of Congress, whereby such unused quotas could be made available to the Department, a great deal of valuable matter would go into circulation which at present is not used in any way.

It is gratifying to be able to report that Congress at its last session adopted a resolution authorizing the Superintendent of Documents to utilize the funds received by him from the sale of public documents to reprint such as are in continuous demand, subject to the approval of the head of the Department from which the document to be reprinted had emanated. This official courteously supplies the information that out of a total of 47,800 Government documents disposed of by him during the fiscal year, for which he received the sum of $12,606.17, 31,860 were publications of this Department, and the amount received therefor was $4,309.60. This again testifies in a marked manner to the increasing appreciation of the work of the Department, especially in view of the very large gratuitous distribution, not only directly through the Department, but also through members of Congress.

Every effort has been made to reduce the cost of printing. The editions have been restricted to actual and urgent requirements, and every means to reduce expenses, short of interfering with efficient service, has been resorted to. In the matter of illustrations especially, originally a very natural source of extravagance, rigid restrictions have been imposed. As a result, notwithstanding the considerable increase in the number of publications and in the total number of pages of new matter, the number of illustrations in the new publications issued during the year has been reduced by over 500, or more than 20 per cent of the previous year.

## THE LIBRARY.

The Department's collection of agricultural and technical scientific literature has been enriched the past year by the addition, by purchase and gifts, of more than 4,000 volumes. As a working library for the practical agriculturist and scientific investigator this collection of books now stands unsurpassed by any single collection. Some of the special collections of technical scientific works rank among the first in the country. More than ever before have the resources of the Library been made available to scientists in various parts of the country. Loans of this nature, which do not interfere with the progress of work in the Department, are greatly appreciated by experiment station workers in particular. Among the many valuable additions to the Library the past year have been a number of rare entomological works, which have long been needed to make the collection of books on this special subject more nearly complete. A printed catalogue of the books on entomology in the Library will be issued in a few months, thus adding another contribution to the printed subject-catalogue of the Library.

In return for the large number of Department publications transmitted to foreign countries through the Library, the number of exchanges from governments, institutions, and societies has greatly increased. These publications cover largely the results of current scientific work abroad and are of signal importance in the work of the Department.

The cataloguing of current accessions has practically been kept up to date. Printed index cards for the Department publications have been issued in larger numbers than before to meet the increasing demand from libraries in all parts of the country which receive the